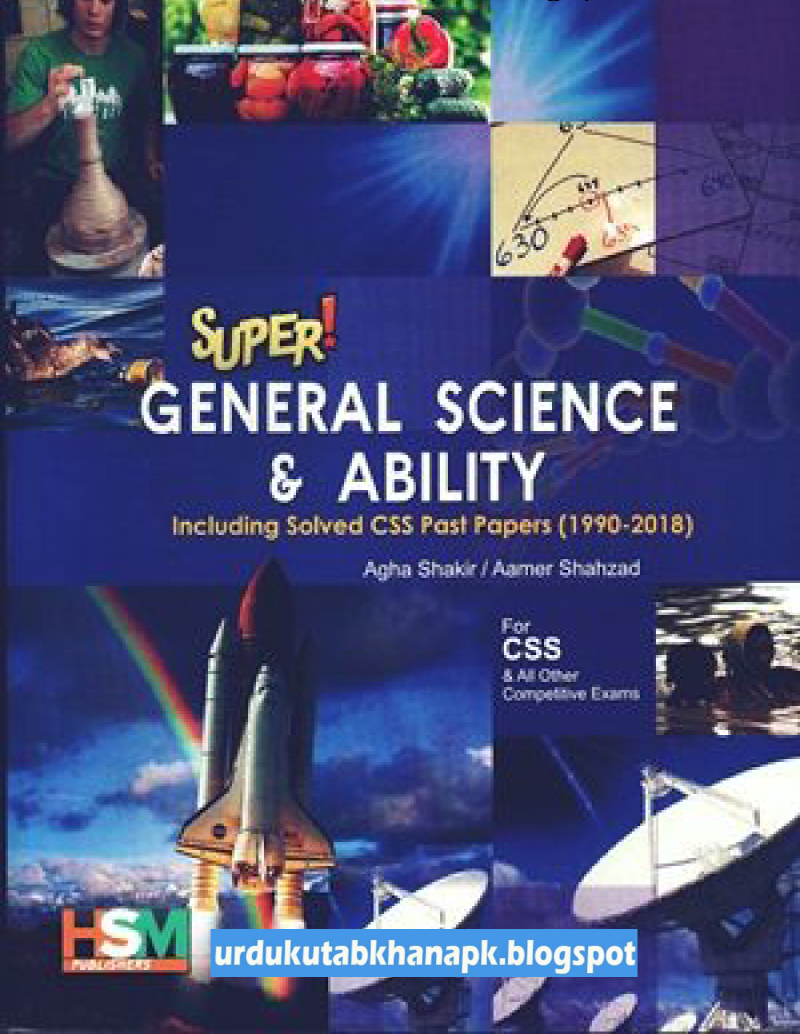

SUPER! GENERAL SCIENCE & ABILITY

Including Solved CSS Past Papers (1990-2018)

Agha Shakir / Aamer Shahzad

For
CSS
& All Other
Competitive Exams

HSM
PUBLISHERS

Revised Scheme and Syllabus *for*

CENTRAL SUPERIOR SERVICES

CSS

COMPETITIVE EXAMINATION

Paper: General Science & Ability (100 Marks)

Part-I (General Science) 60 Marks

I. Physical Sciences

Constituents and Structure:-Universe, Galaxy, Light Year, Solar System, Sun, Earth, Astronomical System of Units.

Process of Nature: - Solar and Lunar Eclipses, Rotation and Revolution, Weather Variables (Global Temperature, Pressure, Circulation, Precipitation, Humidity) and Weather Variations.

Natural Hazards and Disasters: - Earth Quake, Volcanic Eruption, Tsunami, Floods, Avalanche, Travelling Cyclone (Tropical Cyclone, Middle Latitude Cyclone and Tornadoes), Drought, Wildfire, Urban Fire. Disaster Risk Management.

Energy Resources: - Sources of Energy (Renewable i.e. LED Energy, Solar Energy, Wind Energy and Non-Renewable Energy conservation and its sustainable use.

Atomic Structure, Chemical Bonding, Electromagnetic Radiations.

Modern Materials/Chemicals: - Ceramics, Plastics, Semiconductors. Antibiotics, Vaccines, Fertilizers, Pesticides.

II. Biological Sciences

The Basis of Life: - Cell Structures and Functions (Subcellular Organelles such as Nucleus, Mitochondria and Ribosomes).

Biomolecules: - Proteins, Lipids, Carbohydrates and Enzymes.

Plant and Animal Kingdom: - A brief survey of plant and animal kingdom to pinpoint similarities and diversities in nature.

A Brief Account of Human Physiology.

Common Diseases and Epidemics: - Polio, Diarrhea, Malaria, Hepatitis, Dengue their Causes and Prevention.

New Model Concept of Producing BIO Fuel Method

III. Environmental Science

Environment: - The Atmosphere (Layered Structure and Composition). Hydrosphere (Water Cycle, Major Water Compartments), Biosphere (Major Biomes) and Lithosphere (Minerals and Rocks, Rock Types, Plate Tectonics).

Atmospheric Pollution: - Types, Sources, Causes and effects of major air pollutants (COx, Particulate Matter, NOx, SOx, Tropospheric Ozone, Volatile Organic Compounds, Dioxins). Regional and Global air pollution issues (Acid-rain, Ozone Depletion, Greenhouse Effect and Global Warming). International agreements on air pollution control (Montreal Protocol and Kyoto Protocol).

Water Pollution:- Types, sources, causes and effects of major water pollutants (Synthetic Organic Chemicals, Oxygen Demanding Wastes, Plant Nutrients, Thermal Pollution, Infectious Agents, Sediments, Radioactivity, Heavy Metals and Acids). Drinking water quality and standards.

Land Pollution: - Solid waste management and disposal. Role of Remote Sensing and GIS in Environmental Science. Population Planning.

IV. Food Science

Concept of Balance Diet: - Vitamins, Carbohydrates, Protein, Fats and oil, Minerals, Fiber.

Quality of Food:- Bioavailability of Nutrients, Appearance, Texture, Flavor, Quality of Packed and Frozen Food, Food Additives, Preservatives and Antioxidants

Food Deterioration and its Control: - Causes of Food Deterioration, Adulteration, Food Preservation.

V. Information Technology

Computer (Hardware & Software Fundamentals): I/O Processing and data storage, Networking & Internet Standards, Application and business Software, Social Media Websites, Information Systems, Fundamentals of artificial intelligence.

Telecommunications: - Basics of Wireless Communication (Mobile, Satellite, Surveillance and GPS and Fiber Optic etc.

Part-II (General Ability) 40 Marks

VI. Quantitative Ability/Reasoning

Basic Mathematical Skills.

Concepts and ability to reasons quantitatively and solve problems in a quantitative setting.

Basic Arithmetic, Algebra and Geometry (Average, Ratios, Rates, Percentage, Angles, Triangles, Sets, Remainders, Equations, Symbols, Rounding of Numbers

Random Sampling

VII. Logical Reasoning and Analytical Reasoning/Ability

Logical Reasoning includes the process of using a rational, systematic series of steps based on sound mathematical procedures and given statements to arrive at a conclusion

Analytical Reasoning/Ability includes visualizing, articulating and solving both complex and uncomplicated problems and concepts and making decisions that are sensible based on available information, including demonstration of the ability to apply logical thinking to gathering and analyzing information.

VIII. Mental Abilities

Mental Abilities Scales that measures specific constructs such as verbal, mechanical numerical and social ability.

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Physical Science

Astronomy

Universe

Q: Describe different methods to estimate the age of the Universe (CSS-2018)

Methods for Measuring the Age of the Universe

When we speak of "the age of the Universe," we're talking about how much time has past since the Universe could first be described by the hot Big Bang until the present day.

According to research, the universe is approximately 13.8 billion years old. How did scientists determine how many candles to put on the universe's birthday cake? They can determine the age of the universe using two different methods:

1. **Age of galaxies from the travel time of light**
2. **Age of the universe from expansion**

Under the laws of General Relativity, if you have a Universe like ours, which is:

- of uniform density on the largest scales,
- which has the same laws and general properties at all locations,
- which is the same in all directions, and
- in which the Big Bang occurred at all locations everywhere at once, then there is a unique connection between how old the Universe is and how it's expanded throughout its history.

In other words, if we can measure how the Universe is expanding today and how it has expanded throughout its entire history, we can know exactly what all the different components are that make it up. We learn this from a whole host of observations, including:

- From direct measurements of the brightnesses and distances of objects in the Universe such as stars, galaxies and supernovae, allowing us to construct the cosmic distance ladder
- From measurements of large-scale-structure, the clustering of galaxies, and from baryon acoustic oscillations
- And from the fluctuations in the cosmic microwave background, a "snapshot" of the Universe when it was a mere 380,000 years old.

You put all of these things together, and you get a Universe that is made up, *today*, of 68% dark energy, 27% dark matter, 4.9% normal matter, about 0.1% neutrinos, about 0.01% radiation, and pretty much nothing else. But you throw in how the Universe is expanding today.

and we can extrapolate this back in time, and learn the entire expansion history of the Universe, and hence, its age.

The number we get—most precisely from Planck but augmented from the other sources like supernova measurements, the HST key project and the Sloan Digital Sky Survey—is that the Universe is **13.81 billion years old**, with an uncertainty of just 120 million years. This means we're confident in the age of the Universe to 99.1% accuracy, which is an amazing feat!

If the Universe had the same current properties today but were made of 100% normal matter and no dark matter or dark energy, our Universe would be only 10 billion years old. If the Universe were 5% normal matter (with no dark matter or dark energy) and the Hubble constant were 50 km/s/Mpc instead of 70 km/s/Mpc, our Universe would be a whopping 16 billion years old. With the combinations of things we have today, however, we can confidently state 13.81 billion years is the age of the Universe, with a very small uncertainty. It's an incredible feat of science.

Definition *for* Universe

The universe is defined as everything that exists, has existed, and will exist including all physical space, time, matter and energy, the planets, stars, galaxies, and the contents of intergalactic space The universe is currently estimated at roughly 13.7 billion years old, give or take 130 million years. In comparison, the solar system is only about 4.6 billion years old. This estimate came from measuring the composition of matter and energy density in the universe.

- **Astronomy** is the science which investigates all the matter-energy in the universe: its distribution, composition, physical states, movements, and evolution. It is concerned with the evolution, physics, chemistry, meteorology, and motion of celestial objects, as well as the formation and development of the Universe. Astronomy is one of the oldest sciences
- **Cosmology:** Astronomy also includes cosmology, which is the study of the structure, origin, and evolution of the universe. Cosmology is the branch of astronomy involving the origin and evolution of the universe, from the Big Bang to today and on into the future. According to NASA, the definition of cosmology is "the scientific study of the large scale properties of the universe as a whole."
- **Astrology** is not to be confused with Astronomy, which is a natural scientific study of celestial objects, such as stars, planets, comets, nebulae, star clusters and galaxies. Astrology is the study of the movements and relative positions of celestial bodies interpreted as having an influence on human affairs and the natural world. In other words, this consists of a number of belief systems which hold that there is a relationship between astronomical phenomena and events in the human world. *If astrology is defined as a study does it make a science? No,* many fields like philosophy or theology are defined as a study and are not sciences.

Evolution of Cosmolgical Theories

Cosmology is the study of universe as a whole, including its distant past and its future. It is the study of the general nature of the universe. What is the universe now? What was it in the past and what is it likely to be in the future? How was the universe created? These are the basic themes of cosmology. Men have been examining and wondering about the sky for many millennia. As scientific discoveries have been made, ideas about the origin of the universe have changed and are still changing

Ptolemy's Geocentric Theory

A *Geocentric theory* is an astronomical theory which describes the universe as a *geocentric system, i.e.,* a system which puts the Earth in the center of the universe, and describes other objects from the point of view of the Earth. Ptolemy proposed his geocentric theory in the 2nd century A.D. According to his theory, the earth stood at the center, surrounded by some eight spheres, the Moon,

the Sun, the stars, and the five other planets known till the time: Mercury, Venus, Mars, Jupiter, and Saturn.

The geocentric theory was considered to be profoundly mistaken at that time. Since the advent of relativity theory in the early 1900s, the laws of physics have been written in covariant equations, meaning that they are equally valid in any frame. Heliocentric and geocentric plotting systems are both used today, depending on which allows more convenient calculations.

Sun centered Universe *(Heliocentric Theory)*

In the early 1500s, when virtually everyone believed Earth was the center of the universe, Polish scientist Nicolaus Copernicus proposed that the planets instead revolved around the sun. Although his model wasn't completely correct, it formed a strong foundation for future scientists to build on and improve mankind's understanding of the motion of heavenly bodies.

Copernicus' ideas, published only two months before he died, took nearly a hundred years to seriously take hold. When Galileo Galilei claimed in 1632 that Earth orbited the sun, building upon the Polish astronomer's work, he found himself under house arrest for committing heresy against the Catholic Church

Despite this, the observations of the universe proved the two men correct in their understanding of the motion of celestial bodies. Today, we call the model of the solar system, in which the planets orbit the sun, a heliocentric or Copernican model.

Origion of the Universe

In 1959 a survey was conducted of scientists across America concerning their understanding of the physical sciences. One particular question asked "What is your concept of the age of the Universe?" More than two thirds of the scientists polled responded that there was no origin of the Universe. They believed that the Universe was eternal.

Then five years later, in 1964, radio astronomers Arno Penzias and Robert Wilson discovered a microwave signal buried in their data. They attempted to filter out the signal, assuming that it was merely unwanted noise. However, they soon realized what the signal actually was; they had inadvertently discovered the Cosmic Microwave Background (CMB). The CMB had been predicted by a theory that few believed at the time called the Big Bang. This discovery was the first evidence that the Universe had a beginning

The Big Bang

Q: Briefly describe what is big bang theory. (CSS-2011)

The Big Bang

Once it was understood that the Universe had a beginning, scientists began to ask "*how* did it come into existence, and *what* existed before it?"

Most scientists now believe that the answer to the first part of the question is that the Universe sprang into existence from a singularity -- a term physicists use to describe regions of space that defy the laws of physics. We know very little about singularities, but we believe that others probably exist in the cores of black holes.

The second part of the question, as to what existed before the Big Bang, has scientists baffled. By definition, nothing existed prior to the beginning, but that fact creates more questions than answers. For instance, if nothing existed prior to the Big Bang, what caused the singularity to be created in the first place?

Once the singularity was created (however it happened), it began to expand through a process called inflation. The Universe went from very small, very dense, and very hot to the cool expanse that we see today. This theory is now referred to as the Big Bang, a term first coined by Sir Fred Hoyle during a British Broadcasting Corporation (BBC) radio broadcast in 1950.

Interestingly, there really wasn't any sort of explosion (or bang) as the name suggests, but rather the rapid expansion of space and time. It is like blowing up a balloon, as you blow air in, the exterior of the balloon expands outward.

The Moments after the Big Bang

The early Universe was not bound by the laws of physics as we know them today. Consequently, we cannot predict with great accuracy what the Universe looked like during the first minutes of creation. In spite of this, scientists have been able to construct an approximate representation of how the Universe evolved.

Scientists believe that the Universe was initially so hot and dense, that even elementary particles like protons and neutrons could not exist. Instead, different types of matter (called matter and anti-matter) collided together, creating pure energy. But as the Universe began to cool during the first few minutes, protons and neutrons began to form. Then slowly over time these protons, neutrons and electrons came together to form Hydrogen and small amounts of Helium. During the billions of years that followed, stars, planets and galaxies formed to create the Universe as we see it today

Alternatives to the Big Bang Theory

While the Big Bang theory is the most widely accepted theory about the origins of the Universe, and is supported by all the observational evidence, there are other models that explain the evidence equally well.

Some of the other theories argue that the Big Bang theory is based on a false premise -- that the Universe is built on an ever expanding space-time. Some, instead, prefer to build theories on a static Universe, which is what was originally predicted by Einstein's theory of general relativity. Einstein's theory was only later modified to accommodate the way the Universe appears to be expanding.(*Reference: From John P. Millis, Ph.D)*

Galaxy

Q: What is galaxy? The Earth belongs to which galaxy? (CSS 2011)

Galaxy

A galaxy is a large scale aggregate of stars, plus some gas, dust, and possibly. Solar systems, which are held together by gravity.

Early astronomers would look into the Universe with Their telescopes and notice "milky" areas that they could not be defined as one star. Sir William Herschel, in the late 1700's, counted stars and recorded them, developed a notion of the Galaxy. The Galaxy referred to our own Milky Way with its billions of stars, with our Sun and planets being a component. Other galaxies were found throughout the Universe. These islands of stars had different shapes and sizes. The Andromeda Galaxy is spiral, and is larger than our Milky Way Galaxy.

Types of Galaxies

There are many different shapes, sizes and types of galaxies. And while some galaxies may look similar, they are all unique.

Galaxies are classified into four types; these are *Spiral, Barred Spiral, Elliptical* and *Irregular*. Spiral and Barred Spiral galaxies are further divided into three subdivisions a, b and c depending on how tightly the arms are wound. They are therefore referred to as Sa, Sb and Sc or SBa, SBb and SBc. *Elliptical* galaxies have seven subdivisions ranging from E0 for those that appear round to E7 for those that are nearly cigar shaped.

middle aged stars

Spirals are usually large and have a bright central ball of stars with curved arms spreading out from the ball to form a flat disc. Like our own galaxy 'The Milky Way', many galaxies other galaxies have spiral arms. Some have arms like curved spokes in a wheel some gently curved some tightly wrapped around the central ball. Others have what looks like a straight bar of stars extending out from the central ball with the spiral arms attached to ends of the bar, these are known as Barred Spiral Galaxies. Spiral galaxies are classified as a, b or c depending on how tight the arms are wound preceded by S for Spiral and SB for barred. *e.g.* **Sa** or **SBc**. The Great Andromeda Spiral Galaxy is our closest spiral neighbour and can even be seen with the naked eye on a very clear night and from a dark location. older stars.

- **Elliptical Galaxies** are huge balls of thousands of millions of stars. They do not have spiral arms but are elliptical (*egg shaped*). Many of these Elliptical Galaxies are the largest of all star groups, some having many hundreds of billions of stars and even up to a trillion stars. Elliptical Galaxies are classified according to how flattened they are, nearly round ones are known as E0 and sausage shaped ones E7. Most Elliptical Galaxies are very far away and therefore very faint and need a telescope to see them. There are some indications that the giant elliptical galaxies grew from the collision of two or more smaller galaxies. There are indeed some galaxies which can be seen in the process of colliding and possibly combining. has not defined shape. young stars.
- **Irregular galaxies** are as the name implies large groups of stars but with no classifiable shape, in other words they may be any shape. Our Milky Way Galaxy is one of the two main galaxies in what is known as the Local Group comprised of about 30 associated galaxies. Our spiral and the other spiral known as M31 or The Great Andromeda Spiral, have smaller irregular galaxies associated with them as satellite galaxies. Ours can be seen from the southern hemisphere as islands broken off the Milky Way and are known as the Magellanic Clouds. We cannot see the Megellanic Clouds from Britain because they are too far south but are visible with the naked eye further south. Some large elliptical galaxies have huge numbers of satellite galaxies comprised of all the other types, forming a large family. It is thought that our galaxy may have as many as ten small irregular galaxies in attendance.

Milky Way

Q: What do you know about the Milky Way? (CSS- 1987)

Milky Way

The Milky Way, or simply the Galaxy, is the galaxy in which the Solar System is located. It is a barred spiral galaxy that is part of the Local Group of galaxies. It is one of billions of galaxies in the observable universe The Milky Way contains at least 100 billion stars and may have up to 400 billion stars. All the objects in the Milky Way Galaxy orbit their common center of mass, called the *Galactic Center*

Features of the Milky Galaxy

1. The Milky Way is a barred spiral galaxy, about 100,000 light-years across.
2. The Milky Way also contains two significant minor arms, as well as two smaller spurs. One of the spurs, known as the Orion Arm, contains the sun and the solar system. The Orion arm is located between two major arms, Perseus and Sagittarius.
3. The solar system lies about 30,000 light-years from the galactic center, and about 20 light-years above the plane of the galaxy.

4. The Milky Way contains over 200 billion stars, and enough dust and gas to make billions more.
5. At the center of the galaxy is the galactic bulge. The heart of the Milky Way is crammed full of gas, dust, and stars.
6. More than half the stars found in the Milky Way are older than the 4.5 billion year old sun.
7. The most common stars in the galaxy are red dwarfs, a cool star about a tenth the mass of the sun.
8. As late as the 1920s, astronomers thought all of the stars in the universe were contained inside of the Milky Way. It wasn't until Edwin Hubble discovered a special star known as a Cepheid variable, which allowed him to precisely measure distances, that astronomers realized that the fuzzy patches once classified as nebula were actually separate galaxies.

Future of the Universe:

Astronomers recognize four models of possible futures for the Universe.

- **Closed Model:** According to the closed model theory, many billions of years from now, expansion will slow, stop and the Universe will contract back in upon itself.
- **Flat Model:** In the flat model, the Universe will not collapse upon itself, but expansion will slow and the immense will approach a stable size.
- **Open Model:** According to the open model, the Universe will continue expanding forever.
- **Cyclic Model:** Cyclic model states that Universe will collapse, then there will be a Big-Bang again, it will expand first and will collapse again. This cycle will go on.

Ref: Peter Kien-Hong Yu

Dark Matter and Dark Energy

Q: Explain the terms Dark Energy and Dark Matter (CSS-2018)

Dark Matter

In calculating the total mass-energy of the universe, astrophysicists find that baryonic matter, the type composed of atoms, accounts for only about 4 percent of the total mass-energy of the universe. The remaining 96 percent of mass is about 21 percent dark matter and 75 percent dark energy.

Dark matter has been impossible to investigate directly because it does not interact with electromagnetic radiation --visible light, infrared, etc. It has so far been identified only by its effects, especially its gravitational effects on galaxies and other large-scale entities, and also by its influence on the cosmic background radiation.

In the early universe, dark matter played a dominant role in the formation of the early galaxies. The cold gases in the universe gravitated to scattered dark matter densities. Where sufficient gas accumulated, star clusters and galaxies formed. Astronomers today maintain that each galaxy is enveloped in a halo of dark matter, and the halo applies so much force that the outside edge of a galaxy rotates about as fast as the deep interior. It is the halo of dark matter that prevents a galaxy from flying apart.

Astronomers discovered dark matter by inference when they tried to account for the fact that the outer edge of galaxies rotated unexpectedly fast. This unexpected phenomenon could occur only in the presence of a tremendous force. In addition, calculations showed that the mass of galaxies far exceeded the mass of their respective baryonic matter. These findings indicated the presence of some other type of matter, a type much more massive than baryonic matter, and virtually

invisible. Dark matter does not interact with our normal matter except by its gravitational signature.

There are many candidates for the source of dark matter. Neutrinos were of interest for some time, as as these particles are especially profuse in the universe and do not interact with baryonic matter. However, neutrinos account for only a miniscule percent of the total amount of dark matter. A particle predicted by string theory, the neutralino, is another candidate; and another possibility is a theoretical particle called an axion. Some of the elusive dark matter may be baryonic matter of a particularly non-interacting type. But all these candidates are speculation for the time being. One of the objectives of the CERN Large Hadron Collider is to identify dark matter.

Dark Energy

Like dark matter, dark energy is understood by its effects, and scientists really have no idea what it is. It is the force thought to be responsible for the observed accelerating expansion of the universe. In that expansion, objects most distant from us are speeding away faster than those that are closer. Dark energy is one of the major mysteries of the universe, subject to a host of hypotheses. A real explanation may be have to wait for a technological probe that is able to analyze it.

Black Hole

Q: Define the term Black Hole. What's expected inside it?

(CSS 2007/ 2018)

A black hole is a place in space where gravity pulls so much that even light can not get out. The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.

Because no light can get out, people can't see black holes. They are invisible. Space telescopes with special tools can help find black holes. The special tools can see how stars that are very close to black holes act differently than other stars.

This soon may change. An audacious global project called the Event Horizon Telescope is currently working to piece together an image of a black hole for the first time. And if it does, it will be a remarkable accomplishment. Because as massive black holes are, they're actually incredibly hard to see up close.

How Big Are Black Holes?

Black holes can be big or small. Scientists think the smallest black holes are as small as just one atom. These black holes are very tiny but have the mass of a large mountain. Mass is the amount of matter, or "stuff," in an object.

Another kind of black hole is called "stellar." Its mass can be up to 20 times more than the mass of the sun. There may be many, many stellar mass black holes in Earth's galaxy. Earth's galaxy is called the Milky Way.

The largest black holes are called "supermassive." These black holes have masses that are more than 1 million suns together. Scientists have found proof that every large galaxy contains a supermassive black hole at its center. The supermassive black hole at the center of the Milky Way galaxy is called Sagittarius A. It has a mass equal to about 4 million suns and would fit inside a very large ball that could hold a few million Earths.

How Do Black Holes Form?

Scientists think the smallest black holes formed when the universe began.

Stellar black holes are made when the center of a very big star falls in upon itself, or collapses. When this happens, it causes a supernova. A supernova is an exploding star that blasts part of the star into space.

Scientists think supermassive black holes were made at the same time as the galaxy they are in.

If Black Holes Are "Black," How Do Scientists Know They Are There?

A black hole can not be seen because strong gravity pulls all of the light into the middle of the black hole. But scientists can see how the strong gravity affects the stars and gas around the black hole. Scientists can study stars to find out if they are flying around, or orbiting, a black hole.

When a black hole and a star are close together, high-energy light is made. This kind of light can not be seen with human eyes. Scientists use satellites and telescopes in space to see the high-energy light.

What could be inside a black hole?

A black hole has a boundary, called the event horizon. It is where gravity is just strong enough to drag light back, and prevent it escaping. Because nothing can travel faster than light, everything else will get dragged back also. Falling through the event horizon, is a bit like going over Niagra Falls in a canoe.

The Solar System

(CSS 2008/2009)

Our solar system consists of the sun, planets, dwarf planets (or plutoids), moons, an asteroid belt, comets, meteors, and other objects. The sun is the center of our solar system; the planets, over 61 moons, the asteroids, comets, meteoroids and other rocks and gas all orbit the Sun. Our solar system is always in motion. Eight known planets and their moons, along with comets, asteroids, and other space objects orbit the Sun. The Sun is the biggest object in our solar system. It contains more than 99% of the solar system's mass. Astronomers think the solar system is more than 4.5 billion years old.

Sun

The sun lies at the heart of the solar system, where it is by far the largest object. It holds 99.8 percent of the solar system's mass and is roughly 109 times the diameter of the Earth — about one million Earths could fit inside the sun.

Structure of the Sun

The Core

The Sun's core has a tremendously high temperature and pressure. The temperature is roughly 15 million °C. At this temperature, nuclear fusion occurs, turning four hydrogen nuclei into a single helium nucleus plus a LOT of energy. This "hydrogen burning" releases gamma rays (high-energy photons) and neutrinos (particles with no charge and almost no mass).

The Photosphere

This is the lower atmosphere of the Sun and the part that we see (since it emits light at visible wavelengths). This layer is about 300 miles (500km) thick. The temperature is about 5,500 °C.

The Chromosphere

This reddish layer is an area of rising temperatures. The temperature ranges from 6,000 °C (at lower altitudes) to 50,000 °C (at higher altitudes). This layer is a few thousand miles (or kilometers) thick. It appears red because hydrogen atoms are in an excite state and emit radiation near the red part of the visible spectrum. The Chromosphere is visible during solar eclipses (when the moon blocks the Photosphere).

The Corona

This is the outer layer of the Sun's atmosphere. The corona extends for millions of miles and the temperatures are tremendous, reaching one million °C.

Solar Wind

The solar wind is a continuous stream of ions (electrically charged particles) that are given off by magnetic anomalies on the Sun. The solar wind is emitted where the Sun's magnetic field loops out into space instead of looping back into the Sun. These magnetic anomalies in the Sun's corona are called coronal holes. In X-ray photographs of the Sun, coronal holes are black areas.

It takes the solar wind about 4.5 days to reach Earth; it has a velocity of about 250 miles/sec (400 km/sec). Since the particles are emitted from the Sun as the Sun rotates, the solar wind blows in a pinwheel pattern through the solar system. The solar wind affects the entire Solar System, including buffeting comets' tails away from the Sun, causing auroras on Earth (and some other planets), the disruption of electronic communications on Earth, pushing spacecraft around, etc.

Sunspots

Sunspots are relatively cool, dark patches on the sun's surface. They come in many shapes and sizes; they often appear in groups. These spots are much bigger than the Earth; they can be over 10 times the diameter of the Earths.

Temperatures in sunspots are much cooler than elsewhere on the Sun. Usually the Sun's surface temperature is about 5,500 °C (9,900 °F) but in sunspots, the temperature is between 2,700 °C to 4,200 °C (4,900 °F to 7,600 °F). The Sun, like many objects in the Solar System (including Earth) has a magnetic field. A magnetic field is basically invisible magnetic lines (flux) travelling into and out of the Sun produced by electrically charged particles. These lines would usually travel through the Sun regularly, or, in other words, following the route they took when they entered it. However, as the Sun is a ball of gas, it spins faster towards its equator than towards its poles. This muddled way of spinning (known as differential rotation) disturbs the route of the magnetic field, and causes some of the lines of magnetism to warp and twist. Sometimes they become so distorted that they "snap" like elastic bands and pop out of the Sun's surface. The intense magnetism in these magnetic fields lines is powerful enough to push back some of the hot gases travelling outwards from the Sun. This prevents some of the heat from reaching the surface and causes the area to be cooler. And as heat energy also produces light, areas - or spots - where the Sun is cooler are also darker than other areas, and they become known as sunspots.

The sunspot cycle was discovered by S. Heinrich Schwabe in 1843 (he started his observations in 1826).

Explosions in the Corona‹Solar Flares and Coronal Mass Ejections

Studies of the corona reveal dramatic, violent events called solar flares and coronal mass ejections (CMEs). Solar flares release energy from magnetic loops in the corona, heating the gases of the corona and sending particles and radiation out into the solar system. A coronal mass ejection occurs when an explosion in the corona pushes millions or billions of metric tons of material out into space. The frequency of occurrence of both solar flares and CMEs follows the pattern of the 11-year sunspot cycle (as the number of sunspots increases, so does the number of solar flares and CMEs). Both kinds of solar explosions seem to result from the sudden release of energy stored in coronal magnetic fields.

Important Features of the Sun (CSS 2009)

- Mass: 1.98892 x 10^{30} kg
- The diameter of the Sun is 1.391 million kilometers or 870,000 miles.(It holds 99.8 percent of the solar system's mass and is roughly 109 times the diameter of the Earth – about one million Earths could fit inside the sun.Diameter of the Sun in kilometers: 1,391,000 km , Diameter of the Sun in miles: 864,000 miles , Diameter of the Sun in meters: 1,391,000,000 meters)
- The circumference of the Sun is 4,379,000 km.)
- The sun lies at the heart of the solar system, where it is by far the largest object.
- The visible part of the sun is roughly 10,000 degrees F (5,500 degrees C), while temperatures in the core reach more than 27 million degrees F (15 million degrees C), driven by nuclear reactions.
- One would need to explode 100 billion tons of dynamite every second to match the energy produced by the Sun.

- The radius of the Sun, the measurement from the exact center of the Sun out to its surface, is 695,500 kilometers. (Radius of the Sun in miles: 432,200 miles , Radius of the Sun in meters: 695,500,000 meters , Radius of the Sun compared to Earth: 109 Earths)
- The density of the Sun is 1.4 grams per cubic centimeter.
- The volume of the Sun is 1.412 x 10^{18} km^3.
- The sun is one of more than 100 billion stars in the Milky Way
- It orbits some 25,000 light years from the galactic core, completing a revolution once every 250 million years or so.
- The sun is relatively young, part of a generation of stars known as Population I, which are relatively rich in elements heavier than helium.
- The sun was born roughly 4.6 billion years ago.
- The sun has enough nuclear fuel to stay much as it is now for another 5 billion years.

The Planets *and* their Characteristics

(CSS 1986/2002/2004/2011)

New definition of planet adopted by IAU

The IAU has adopted a new definition of "planet" and Pluto no longer qualifies. (CSS 2011)

On 24 August 2006 members of the International Astronomical Union (IAU) agreed that a "planet" is defined as a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit. A "dwarf planet" is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.

All other objects, except satellites, orbiting the Sun shall be referred to collectively as "Small Solar-System Bodies". An IAU process will be established to assign borderline objects into either dwarf planet and other categories. These currently include most of the Solar System asteroids, most Trans-Neptunian Objects (TNOs), comets, and other small bodies.

This means that the Solar System consists of eight "planets" Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. A new distinct class of objects called "dwarf planets" was also decided. It was agreed that "planets" and "dwarf planets" are two distinct classes of objects. The first members of the "dwarf planet" category are Ceres, Pluto and 2003 UB 313 (*temporary name*).

2003 UB313, discovered on October 21, 2003, is the largest known dwarf planet in the solar system.

Planet is the term used for a body in orbit around the Sun. The word comes from the Greek *planetes*, and means "wanderers." Our solar system has eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Since 1994, evidence has been found that planets also exist beyond our solar system. At least 322 planets existing in other solar systems have been discovered.

Inner, Rocky, Inferior Plantes

The inner planets are the planets in the inner part of the Solar System that orbit closest to the sun. The 4 inner planets are Mercury, Venus, Earth, and Mars. There are a number of differences between the inner and outer planets aside from location. The inner planets are composed mostly of rock Gene rally, inner planets are both smaller and denser than their counterparts. They also have few or no moons and no rings circling them Mercury is the closest planet to the Sun Venus is the hottest planet in the solar system Venus is often called the morning star because, with the exception of Earth's moon, it's the brightest object in the sky. The planet has no moon of its own Earth is the third inner planet. Like Mercury, the Earth has an internal magnetic field. The planet, which only has one moon, is comprised of a mixture of various rocks and minerals. Mars is also known as the Red Planet due to the rust of iron-rich materials that form the planet's surface.

Outer, Jovian, Gaseous or Superior Planets

The outer planets, also called Jovian planets or gas giants, are gaseous with no solid surfaces and only liquid cores. The outer planets are so much larger than the inner planets that they comprise 99% of the mass of the celestial objects orbiting our Sun. All of the outer planets have rings, although Saturn's are the most noticeable. Jupiter is distinctive for a number of reasons. In addition to being the largest and most massive planet, it also has the most moons – 63 discovered so far. Jupiter's rings are very faint and difficult to see. Saturn is best known for its distinctive ring system, which can seen from Earth by the naked eye. Uranus, which is the only planet to rotate on its size, has 27 known moons. Many satellites have names from mythology, but Uranus' moons are named after characters from the works of Alexander Pope and Shakespeare. Some of the satellites are Titania, Oberon, and Umbriel. Neptune is the last outer planet and the final planet in the Solar System. With only 13 moons, it has the least number of satellites of any of the outer planets.

Why Is Pluto Not Called a Planet Anymore? (CSS 2004/2005)

In 2003, an astronomer saw a new object beyond Pluto. The astronomer thought he had found a new planet. The object he saw was larger than Pluto. He named the object Eris (EER-is). Finding Eris caused other astronomers to talk about what makes a planet a "planet." There is a group of astronomers that names objects in space. This group decided that Pluto was not really a planet because of its size and location in space. So Pluto and objects like it are now called dwarf planets. Pluto is also called a plutoid. A plutoid is a dwarf planet that is farther out in space than the planet Neptune. The three known plutoids are Pluto, Eris and Makemake (MAH-kee-MAH-kee). Astronomers use telescopes to discover new objects like plutoids. Scientists are learning more about the universe and Earth's place in it. What they learn may cause them to think about how objects like planets are grouped. Scientist's group objects that are like each other to better understand them. Learning more about faraway objects in the solar system is helping astronomers learn more about what it means to be a planet.

Mercury (CSS 2004)

1. Mercury was known since at least Sumerian times roughly 5,000 years ago, where it was often associated with Nabu, the god of writing
2. Mercury is the closest planet to the sun
3. Mercury is the smallest planet — it is only slightly larger than Earth's moon.
4. Mercury is the second densest planet after Earth, with a huge metallic core roughly 2,200 to 2,400 miles (3,600 to 3,800 km) wide, or about 75 percent of the planet's diameter. In comparison, Mercury's outer shell is only 300 to 400 miles (500 to 600 km) thick.
5. A completely unexpected discovery Mariner 10 made was that Mercury possessed a magnetic field. The recent discovery from 2007 Earth-based radar observations that Mercury's core may still be molten could help explain its magnetism
6. Mercury speeds around the sun every 88 Earth days, traveling through space at nearly 112,000 mph (180,000 kph), faster than any other planet
7. No atmosphere: Mercury possesses an exosphere containing 42 percent oxygen, 29 percent sodium, 22 percent hydrogen, 6 percent helium, 0.5 percent potassium, with possible trace amounts of argon, carbon dioxide, water, nitrogen, xenon, krypton and neon.
8. *Magnetic field:* Roughly 1 percent the strength of Earth's.
9. *Average distance from the sun:* 35,983,095 miles (57,909,175 km) By Comparison: 0.38 Earth's distance from the Sun.
10. *Length of Day:* 58.646 Earth days
11. The first spacecraft to visit Mercury was Mariner 10, which imaged about 45 percent of the surface and detected its magnetic field.

12. NASA's MESSENGER orbiter is the second spacecraft to visit Mercury. When it arrived in March 2011, MESSENGER became the first spacecraft to orbit Mercury, where it continues to study the planet.

Venus (CSS 2003)

The second planet from the Sun, is named for the ancient Roman goddess of love and beauty. The planet — the only planet named after a female

1. Venus was once thought to be two different stars, the evening star and the morning star — that is, the ones that first appeared at sunset and sunrise.
2. *Venus* and *Earth* are often called twins because they are similar in size, mass, density, composition and gravity.
3. Venus is the hottest world in the solar system (870 degrees F *(465 degrees C)*)
4. The surface of Venus is extremely dry. There is no liquid water on its surface because the scorching heat would cause any to boil away.
5. Venusian surface is covered by flat, smooth plains that are marred by thousands of volcanoes, ranging from about 0.5 to 150 miles (0.8 to 240 kilometers) wide, with lava flows carving long, winding canals up to more than 3,000 miles (5,000 kilometers) in length, longer than on any other planet.
6. Venus has coronae, or crowns — ring like structures that range from roughly 95 to 360 miles (155 to 580 kilometers) wide
7. Venus is brighter than any other planet or even any star in the night sky because of its highly reflective clouds and its closeness to our planet.
8. Venus takes 243 Earth days to rotate on its axis, by far the slowest of any of the major planets
9. Venus magnetic field is 0.000015 times that of Earth's field
10. Venus' metallic iron core is roughly 2,400 miles (6,000 kilometers) wide
11. Venus' molten rocky mantle is roughly 1,200 miles (3,000 kilometers) thick.
12. Venus' crust is mostly basalt, and is estimated to be six to 12 miles (10 to 20 kilometers) thick on average.
13. *Average Distance from the Sun* 67,237,910 miles
14. The winds at the planet's surface are much slower, estimated to be just a few miles per hour.
15. The *Venus Express* spacecraft the *European Space Agency* launched in 2005 intriguingly found evidence of lightning on the planet.
16. Venus has no moons or rings.

Earth (CSS 2000)

1. Earth is the fifth largest of the planets in the solar system — smaller than the four gas giants, Jupiter, Saturn, Uranus and Neptune, *but* larger than the three other rocky planets, Mercury, Mars and Venus.
2. Earth, is the third planet from the sun
3. Earth is the only planet known to have an atmosphere containing free oxygen, oceans of liquid water on its surface, and, of course, life.
4. Earth has a diameter of roughly 8,000 miles (13,000 kilometers)
5. Roughly 71 percent of Earth's surface is covered by water, most of it in the oceans
6. About a fifth of its atmosphere is made up of oxygen, produced by plants

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Colourful planet

7. The Earth spins on an imaginary line called an axis that runs from the North Pole to th South Pole, while also orbiting the sun. It takes Earth 24 hours to complete a rotation c its axis, and roughly 365 days to complete an orbit around the sun.
8. The Earth's axis of rotation is tilted in relation to the ecliptic plane, an imaginary surfac through Earth's orbit around the sun
9. Earth's orbit is not a perfect circle, but is rather an oval-shaped ellipse, like that of th orbits of all the other planets.
10. Earth probably formed at roughly the same time as the sun and other planets some 4. billion years ago
11. The history of Earth is divided into four eons — starting with the earliest, these are th Hadean, Archean, Proterozoic, and Phanerozoic.
12. The atmosphere is roughly 78 percent nitrogen, 21 percent oxygen, with trace amounts of water, argon, carbon dioxide and other gases.
13. The lowest layer of the atmosphere is known as the troposphere, which is constantly in motion, causing the weather.
14. The Earth's core consists mostly of iron and nickel and potentially smaller amounts of lighter elements such as sulfur and oxygen. The mantle is made of iron and magnesium-rich silicate rocks. (The combination of silicon and oxygen is known as silica, and minerals that contain silica are known as silicate minerals.)
15. The Earth's core is about 4,400 miles (7,100 kilometers) wide, slightly larger than half the Earth's diameter and roughly the size of Mars
16. The outermost 1,400 miles (2,250 kilometers) of the core are liquid, while the inner core — about four-fifths as big as Earth's moon at some 1,600 miles (2,600 kilometers) in diameter — is solid.
17. *Average Distance from the Sun* 92,955,820 miles (149,597,890 km)
18. *Average Length of Solar Day* 24 hours
19. *Length of Year* 365.24 Earth days
20. *Equatorial Inclination to Orbit* 23.45 degrees

There are several million known species of life, ranging from the bottom of the deepest ocean to a few miles into the atmosphere, and scientists think far more remain to be discovered. Scientists figure there are between 5 million a 100 million species on Earth, but science has only identified about 2 million of them

Mars (CSS 2003/2007)

2nd smallest planet

1. Mars is named after the ancient Roman god of war, as befitting the red planet's bloody color.
2. The bright rust color Mars is known for is due to to iron-rich minerals in its regolith — the loose dust and rock covering its surface.
3. The red planet is home to both the highest mountain and the deepest, longest valley in the solar system
4. Mars has the largest volcanoes in the solar system, including Olympus Mons, which is about 370 miles (600 kilometers) in diameter
5. Many regions of Mars are flat, low-lying plains.
6. Mars is much colder than Earth, in large part due to its greater distance from the sun. The average temperature is about minus 80 degrees F (minus 60 degrees C)
7. The dust storms of the Mars are the largest in the solar system

8. The axis of Mars, like Earth's, is tilted with relation to the sun.
9. *Atmospheric composition (by volume)* 95.32 percent carbon dioxide, 2.7 percent nitrogen, 1.6 percent argon, 0.13 percent oxygen, 0.08 percent carbon monoxide, minor amounts of water, nitrogen oxide, neon, hydrogen-deuterium-oxygen, krypton, xenon
10. Mars currently has no global magnetic field, but there are regions of its crust that can be at least 10 times more strongly magnetized than anything measured on Earth, remnants of an ancient global magnetic field.
11. *Average Distance from the Sun* 141,633,260 miles (227,936,640 km)
12. The two moons of Mars, Phobos and Deimos were discovered by American astronomer Asaph Hall
13. The first person to watch Mars with a telescope was Galileo

Saturn

1. Saturn is the sixth planet from the sun and the second largest planet in the solar system
2. Saturn was the Roman name for Cronus, the lord of the Titans in Greek mythology.
3. Saturn is the root of the English word "Saturday."
4. Saturn is a gas giant made up mostly of hydrogen and helium.
5. Saturn is big enough to hold more than 760 Earths
6. Saturn has the lowest density of all the planets
7. Saturn is the farthest planet from Earth visible to the naked human eye.
8. *Atmospheric composition* (by volume) 96.3 percent molecular hydrogen, 3.25 percent helium, minor amounts of methane, ammonia, hydrogen deuteride, ethane, ammonia ice aerosols, water ice aerosols, ammonia hydrosulfide aerosols
9. Saturn has a magnetic field about 578 times more powerful than Earth's.
10. Saturn seems to have a core between about 10 to 20 times as massive as the Earth.
11. **Average distance from the sun**: 885,904,700 miles (1,426,725,400 km) By Comparison: 9.53707 times that of Earth
12. Saturn has at least 62 moons.
13. Saturn's largest moon, Titan, is slightly larger than Mercury
14. Galileo Galilei was the first to see Saturn's rings in 1610

Uranus

methane gas Green planet

1. Uranus is the coldest planet in the Solar System
2. Uranus is the 7th planet from the Sun
3. A day on Uranus is only about 17 hours.
4. The least dense planet in the Solar System is Saturn. The density of Uranus is only 1.27 g/cm^3. In other words, Uranus would sink in water (water is 1 g/cm^3)
5. Uranus has the second most dramatic set of rings in the Solar System.
6. Uranus was the first planet discovered in the modern age
7. At magnitude 5.3, Uranus is just within the brightness scale that a human eye can perceive.
8. Uranus is about 31,763 miles in diameter. It is the 3nd largest planet in our solar system. The Earth could fit 4 times across the diameter of Uranus.
9. Uranus, with no solid surface, is one of the gas giant planets. (*The others are Jupiter, Saturn, and Neptune.*)

Jupiter massive biggest, largest, fastest rotation 67 moons.

10. Only one spacecraft in the history of spaceflight has ever made a close approach to Uranus. NASA's Voyager 2 zipped pass Uranus in January, 1986, coming within 81,000 km of the surface of Uranus.
11. The average temperature in Uranus's atmosphere is -350° F.
12. Uranus has 27 known moons, named mostly for characters from the works of William Shakespeare and Alexander Pope.
13. Uranus was discovered in 1781 by a British astronomer, Sir William Herschel. The planet was originally named Georgian Sidus (Star of George) in honor of the King.

Neptune

orbit ↑. Sun ↑ farthest

Coldest & slowest revolu

1. The planet Neptune was discovered on Sept. 23, 1846
2. In accordance with all the other planets seen in the sky, this new world was given a name from Greek and Roman mythology — Neptune, the Roman god of the sea.
3. Neptune's winds can reach up to 1,500 miles per hour (2,400 kilometers per hour), the fastest detected yet in the solar system.
4. Neptune is the eighth and most distant planet from the sun.
5. Neptune remains the farthest planet from the sun, since Pluto was reclassified as a dwarf planet in 2006.
6. Atmospheric composition (by volume) Hydrogen - 80 percent; Helium - 19.0 percent; Methane - 1.5 percent
7. Composition The overall composition of Neptune is, by mass, thought to be about 25 percent rock, 60 to 70 percent ice, and 5 to 15 percent hydrogen and helium.
8. Average Distance from the Sun 4,498,252,900 km (2,795,084,800 miles)
9. Neptune has 13 known moons,
10. With an equatorial radius of only 24,764 km, Neptune is smaller than the other gas giants in the Solar System: Jupiter, Saturn and Uranus.
11. The gravity of Neptune is only 17% stronger than Earth gravity.
12. Neptune is the coldest planet in the Solar System
13. There are no firm plans to return to Neptune. There are tentative plans from NASA to send a new mission to Neptune called the Neptune Orbiter. This spacecraft would launch in 2016 and take about 14 years to get to Neptune, arriving around 2030.
14. A tiny, mysterious moon orbiting Neptune has been spotted for the first time in more than 20 years in Oct 08 , 2013

Difference between Star and Planet

Key difference: Stars and planets are two different types of astronomical object existing in our universe. A planet is a large object that orbits around a star or a stellar remnant and has atmosphere. A star, on the other hand, is a massive, luminous sphere of plasma that is held together by its gravitational pull. A solar system is usually made up satellites revolving around planets, which are in turn revolving around a star

Star	Planet
Stars are usually made up of two gases, hydrogen and helium	Planets, on the other had are mainly made up to rock and minerals.
A star is generally defined by its ability to generate light via nuclear (fusion) reactions that convert hydrogen into helium.	Planets are formed from the collection of gas and dust that surrounds a star. They do not have the necessary mass, when sufficiently

	compressed by its own gravity, to support the hydrogen-to-helium fusion reactions.
A star has its own light.	A planet has no light of its own. It shines by reflecting the light of the sun.
Stars twinkle at night.	Planets do not twinkle.
The relative positions of the stars do not undergo any noticeable change.	Since planets are very mush closer to the earth than the stars are. their motion around the sun is noticeable as a daily shifting of their relative positions in the sky.
A star has very high temperature	Planets have low temperatures.
There are billions of stars in the celestial sphere.	There are only nine planets in the solar system.
Since the stars are very far away, the telescope can only make them look brighter but not larger.	Most planets on the other hand are near enough to the earth to be magnified by the telescope.

Table *of* Planetary Statistics

Statistics about the solar system's eight planets.

Name of Planet	Average Distance *from Sun*	Diameter	Time to Spin on Axis *(a day)*	Time to Orbit Sun *(a year)*	Gravity *(Earth = 1)*	Average Temperature	Contents of Atmosphere	Number of Known Moons
Mercury	57,900,000 km (36,000,000 miles)	4,878 km (3,031 miles)	59 days	88 days	0.38	-183 °C to 427 °C (-297 °F to 800 °F)	Sodium, helium	None
Venus	108,160,000 km (67,000,000 miles)	12,104 km (7,521 miles)	243 days	224 days	0.9	480 °C (896 °F)	Carbon Dioxide (96%), Nitrogen (3.5%)	None
Earth	149,600,000 km (92,960,000 miles)	12,756 km (7,926 miles)	23 hours, 56 mins	365.25 days	1	14 °C (57 °F)	Nitrogen (77%), Oxygen (21%)	1
Mars	227,936,640 km (141,700,000 miles)	6,794 km (4,222 miles)	24 hours, 37 mins	687 days	0.38	-63 °C (-81 °F)	Carbon Dioxide(95.3%), Argon	2
Jupiter	778,369,000 km (483,500,000 miles)	142,984 km (88,846 miles)	9 hours, 55 mins	11.86 years	2.64	-130 °C (-202 °F)	Hydrogen, Helium	67
Saturn	1,427,034,000 km (888,750,000 miles)	120,536 km (74,900 miles)	10 hours, 39 mins	29 years	1.16	-130 °C (-202 °F)	Hydrogen, Helium	62
Uranus	2,870,658,186 km (1,783,744,300 miles)	51,118 km (31,763 miles)	17 hours, 14 mins	84 years	1.11	-200 °C (-328 °F)	Hydrogen, Helium, Methane	27
Neptune	4,496,976,000 km (2,797,770,000 miles)	49,532 km (30,779 miles)	16 hours, 7 mins	164.8 years	1.21	-200 °C (-328 °F)	Hydrogen, Helium, Methane	13

Note: *The* two distant moons - S/2010 J 1 and S/2010 J 2 - were discovered during routine tracking observations of already known satellites in September 2010.

Two new moons have been discovered orbiting Jupiter, bringing the planet's total number of known satellites to 67.

And, at just two kilometres in diameter, one of the moons may be Jupiter's smallest known satellite. Jupiter has four large moons and dozens of smaller ones Galileo first discovered the four largest moons of Jupiter, Io, Europa, Ganymede, and Callisto in 1610, using a 20-power telescope; these moons are known as the Galilean moons.

Dwarf Planets

According to the International Astronomical Union, which sets definitions for planetary science, a dwarf planet is a celestial body that:

- Orbits the sun.
- Has enough mass to assume a nearly round shape.
- Has not cleared the neighborhood around its orbit.
- Is not a moon.

The main distinction between a dwarf planet and a planet is that planets have cleared the path around the sun while dwarf planets tend to orbit in zones of similar objects that can cross their path around the sun, such as the asteroid and Kuiper belts. Dwarf planets also are generally smaller than the planet Mercury.

The first five recognized dwarf planets are Ceres, Pluto, Eris, Makemake and Haumea. Scientists believe there may be dozens or even more than 100 dwarf planets awaiting discovery. The IAU recognized Pluto's special place in our solar system by designating dwarf planets that orbit the sun beyond Neptune as plutoids. Eris, which orbits far beyond Neptune, is a plutoid while Ceres, which orbits in the main asteroid belt between Mars and Jupiter is a dwarf planet.

Pluto was considered a planet until 2006. The discovery of a similar-sized worlds deeper in the distant Kuiper Belt sparked a debate that resulted in a new official definition of a planet that did not include Pluto.

Dwarf Planets

Name of Dwarf Planet	Average Distance from Sun	Diameter	Time to Spin on Axis (a day)	Time to Orbit Sun (a year)	Average Temperature	Year of Discovery	Number of Moons
Ceres	413,900,000 km (257,031,000 miles)	950 km	9 hours, 5 minutes	4 years, 220 days	-106 °C (-159 °F)	1801	None
Pluto	4,436,820,000 to 7,375,930,000 km	2,390 km	6 days, 9 hours	248 years	-228 °C (-378 °F)	n/a	5
Haumea	5,260,000,000 to	1960 x	4 hours	285	-240 °C	2004	2

	7,708,000,000 km	1518 x 996 km		years	(-400 °F)		
Makemake	5,760,800,000 to 7,939,700,000 km	Between 1300 and 1900 km	7 hours, 46 minutes	309 years	-243 °C (-405 °F)	2005	None
Eris	5,665,500,000 to 14,634,000,000 km	3,000 km	8 hours	557 years	-248 to -232 °C	2005	1

Moon

5th largest moon of solar system

Natural Satellite, a body in space that orbits a larger body. The larger body is referred to as the satellite's primary. Natural satellites that orbit planets are often called moons. The best-known natural satellite is Earth's moon.

The Moon (or Luna) is the Earth's only natural satellite and was formed 4.6 billion years ago around some 30–50 million years after the formation of the solar system. The Moon is in synchronous rotation with Earth meaning the same side is always facing the Earth. The first unmanned mission to the Moon was in 1959 by the Soviet Lunar Program with the first manned landing being Apollo 11 in 1969.

natural sattelite

Though a satellite of Earth, the Moon is bigger than Pluto. Some scientists think of it as a planet (four other moons in our solar system are even bigger), though that viewpoint has never caught on officially.

its size is 1/4th of earth.

Moon Profile

Circumference at Equator	10,917.0 km
Diameter	3,475 km
Mass	73,476,730,924,573,500 million kg (0.0123 x Earth)
Average Distance from Earth	384,400 km
Length of Orbit	27.3 Earth days
Surface Temperature	233 to 123 °C

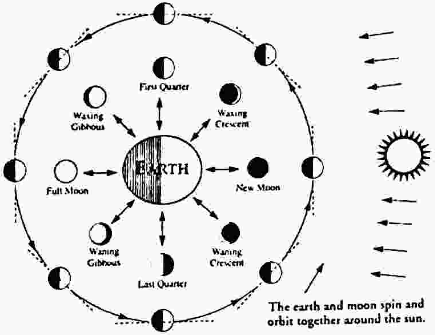
1. At 3,475 km in diameter, the Moon is much smaller than the major moons of Jupiter and Saturn. Earth is about 80 times the volume than the Moon, but both are about the same age.
2. The Moon is moving approximately 3.8 cm away from our planet every year. It is estimated that it will continue to do so for around 50 billion years. By the time that happens, the Moon will be taking around 47 days to orbit the Earth instead of the current 27.3 days.
3. The Moon has much weaker gravity than Earth, due to its smaller mass, so you would weigh about one sixth (16.5%) of your weight on Earth. This is why the lunar astronauts could leap and bound so high in the air.
4. The moon very likely has a very small core just 1 to 2 percent of the moon's mass and roughly 420 miles (680 km) wide.
5. Moon's rocky mantle is about 825 miles (1,330 km) thick and made up of dense rocks rich in iron and magnesium.
6. The average composition of the lunar surface by weight is roughly 43 percent oxygen, 20 percent silicon, 19 percent magnesium, 10 percent iron, 3 percent calcium, 3 percent aluminum, 0.42 percent chromium, 0.18 percent titanium and 0.12 percent manganese.

moon light 1.3 second to reach earth
Gravity of moon = 1/6 g.

7. The moon has a very thin atmosphere, so a layer of dust — or a footprint — can sit undisturbed for centuries. Daytime temperatures on the sunny side of the moon reach 273 degrees F; on the dark side it gets as cold as -243.
8. The legendary scientist Galileo Galilei was the first to use a telescope to make scientific observations of the moon, describing a rough, mountainous surface in 1609 that was quite different from the popular beliefs of his day that the moon was smoot
9. In 1959, the Soviet Union sent the first spacecraft to impact the moon's surface and returned the first photographs of its far side. In 1969, the United States landed the first astronauts on the moon, undoubtedly the most famous of NASA's achievements, and their efforts returned 842 pounds (382 kg) of rocks and soil to Earth for study. It remains the only extraterrestrial body that humanity has ever visited

Phases of Moon

Our Moon orbits around our planet, and this Earth-Moon system orbits around the Sun. The phases of the Moon depend on its position in relation to the Sun and Earth. The Moon does not produce any light of its own—it only reflects light from the Sun. As the Moon moves around the Earth, we see different parts of the near side of the Moon illuminated by the Sun. This causes the changes in the shape of the Moon that we notice on a regular basis, called the phases of the Moon.



The earth and moon spin and orbit together around the sun.

New Moon > New Crescent > First Quarter > Waxing Gibbous > Full Moon > Waning Gibbous > Last Quarter > Old Crescent > *New Moon* (again)

(*There are 8 total phases that the moon goes through.*)

- The *new moon* is when the Moon moves between Earth and the Sun, the side facing Earth is completely dark. This is called the new moon phase, and we do not usually see the Moon at this point
- A *crescent moon* is when the moon is between the new and quarter moon stages. It looks like a "C" shape.

- The *quarter moon* (or a *half moon*) is when half of the moon is visible. If the moon is waxing, it is called the *first quarter*, if the moon is waning, it is the *last quarter*
- A *gibbous moon* is between the quarter and full moon stages. More than half of the moon can be seen, but not all of it.
- The *full moon* is when the moon is all lit up. All of the moon that we can see is lit up by the Sun during the full moon.
    - A second full moon in one calendar month is usually called a *blue moon*. The saying "Once in a blue moon" refers to something that does not happen often, like a blue moon

The Sidereal *and* Synodic Months

The **sidereal month** is the time the Moon takes to complete one full revolution around the Earth with respect to the background stars. However, because the Earth is constantly moving along its orbit about the Sun, the Moon must travel slightly more than 360° to get from one new moon to the next. Thus, the **synodic month**, or **lunar month**, is longer than the sidereal month. A sidereal month lasts 27.322 days, while a synodic month lasts 29.531 days.

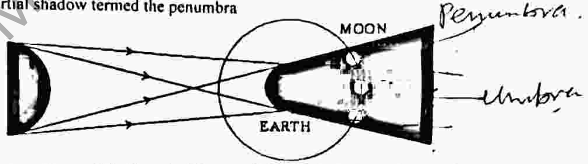
(to block)

Eclipses

An eclipse is the complete or partial obscuring of a celestial body by another other. The term eclipse is most often used to describe either a solar eclipse, when the Moon's shadow crosses the Earth's surface, or a lunar eclipse, when the Moon moves into the Earth's shadow. However, it can also refer to such events beyond the Earth-Moon system:

Explain the formation of Lunar Eclipse (CSS 2017)

The Earth throws a long shadow behind the side facing the Sun. A lunar eclipse occurs when the Moon enters the Earth's shadow. This shadow has two parts: the total shadow called the umbra and the partial shadow termed the penumbra



Relative positions of the Sun, the Moon and the Earth during a lunar eclipse

If the Moon becomes completely immersed into the umbra, a total eclipse occurs; and if only a portion of it falls into the umbra, a partial eclipse occurs.

During totality, the Moon is not completely invisible. This is due to the fact that some sunlight are refracted by the Earth's thin atmosphere into the umbra and illuminate the Moon, making it coppery-red in colour. Its brightness varies for different total eclipses depending on the geometry of the Moon's path through the umbra and also on the Earth's atmospheric conditions. Sometimes the Moon only enters the penumbra without touching the umbra. This is a penumbral lunar eclipse. During a penumbral lunar eclipse, only the apparent brightness of the Moon will become dimmer but the limb of the Moon will not be obscured by the Earth's shadow

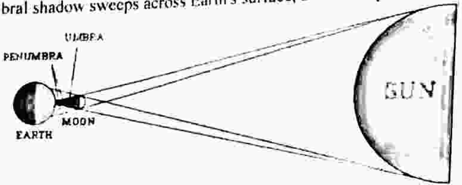
Different stages in Lunar Eclipse

There are 7 stages during the occurrence of an eclipse

1. "Moon enters penumbra" - the first contact of the Moon and the Earth's penumbra
2. "Moon enters umbra" - when the Moon enters the Earth's umbra, this is the start of partial lunar eclipse
3. "Total eclipse begins" - when the Moon touches the umbra internally, at this time, the Moon is totally immersed in the umbra and total eclipse starts
4. "Middle of eclipse" - occurs when the centre of the Moon is closest to the centre of the Earth's umbra
5. "Total eclipse ends" - when the Moon touches the umbra internally again, this signifies the end of total eclipse
6. "Moon leaves umbra" - the time when the Moon touches the umbra externally, this is the end of partial lunar eclipse
7. "Moon leaves penumbra" - when the Moon leaves the penumbra

Solar Eclipse (CSS 2007/ 2017)

Solar eclipse occurs when the Moon is in line between the Earth and the Sun The Moon cast-a shadow on the Earth's surface and obscurs some parts on the Sun. The porportion of the Sun being blocked depends on the position of the observer on the Earth. When only the Moon's penumbral shadow strikes the Earth, a partial eclipse of the Sun is observed. However, if the Moon's dark umbral shadow sweeps across Earth's surface, a total eclipse of the Sun is seen.



Relative positions of the Sun, the Moon and the Earth during a total solar eclipse

Different stages in Solar Eclipse

There are 7 stages during the occurrence of an eclipse

1. "Moon enters penumbra" - the first contact of the Moon and the Earth's penumbra
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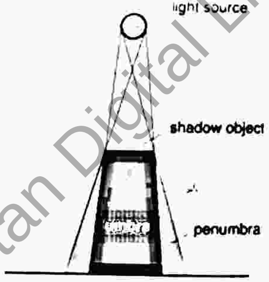


Umbra and Penumbra

(Terms of *physics/lighting)*

The shadow volume behind an object lit by an area *light* source (*in contrast to a point light source*) doesn't have sharp boundaries. This is caused by the fact that each point in the boundary area is only partially shadowed. The area (*volume*) in full shadow is the **umbra**, the boundary area the **penumbra**.

What is the difference between Umbra and Penumbra? (CSS 2002/2005)

The umbra is the dark, inner shadow. If you find yourself in the umbra, the source of light (e.g., the Sun) is completely blocked, as in a total solar eclipse. On the other hand, within the penumbra, the source of light will be partly visible (as when the Sun is partially eclipsed)

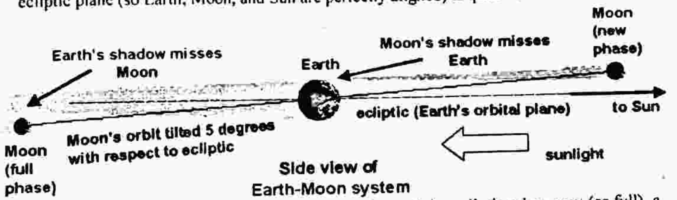
Frequency and Predication of Eclipses

If the plane of the moon's orbit about the earth coincided with that of the earth about the sun, a solar eclipse would be observed each month when the moon is new and a lunar eclipse when the moon is full. However, the moon's orbital plane is tilted at an angle of about 5°10' to the earth's orbital plane, making eclipses possible only when the three bodies are aligned (at new or full moon) and when the moon is crossing the earth's orbital plane (at a point called the node). Within a given year, a maximum of seven eclipses can occur, either four solar and three lunar or five solar and two lunar. Despite the fact that there are more solar than lunar eclipses each year, over time many more lunar eclipses are seen at any single location on earth than solar eclipses. This occurs because a lunar eclipse can be seen from the entire half of the earth facing the moon at that time, while a solar eclipse is visible only along a narrow path on the earth's surface.

From their observations of eclipses the Chaldaeans (fl. 1000 B.C.–540 B.C.) discovered that similar eclipses of the sun recur in cycles of 18 years, 111/3 days; this cycle, called the saros, is an interval in which the sun, earth, and moon return to nearly identical relative positions. Since the orbits of the earth and moon are quite accurately known, eclipses can be predicted far in advance, both in time and location. Similar calculations can determine the time and place of past eclipses; this information is useful for dating historical events that are known to have occurred at the same time as an eclipse.

Why aren't there a solar eclipse at every new Moon and a lunar eclipse at every full Moon?

The answer is that the Moon's orbit is slightly inclined to the ecliptic (at an angle of 5.2°), so the chance that a new (or full) Moon will occur just as the Moon happens to cross the ecliptic plane (so Earth, Moon, and Sun are perfectly aligned) is quite low.


Moon (new phase)
Moon's shadow misses Earth
Earth
Earth's shadow misses Moon
ecliptic (Earth's orbital plane)
to Sun
Moon (full phase)
Moon's orbit tilted 5 degrees with respect to ecliptic
sunlight
Side view of Earth-Moon system

If the Moon happens to lie above or below the plane of the ecliptic when new (or full), a solar (or lunar) eclipse cannot occur. Such a configuration is termed *unfavorable* for producing an eclipse. In a *favorable* configuration, the Moon is new or full just as it crosses the ecliptic plane, and eclipses are seen. Unfavorable configurations are much more common than favorable ones, so eclipses are relatively rare events.

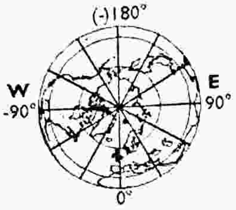
Difference *between* Lunar *and* Solar Eclipse (CSS 2017)

Lunar eclipses happen when the Earth lies between the Sun and Moon hence blocking the sun's rays from reaching the moon, whereas a **solar eclipse** occurs when the moon lies between the Earth and sun and hence blocks the Sun's rays partially.

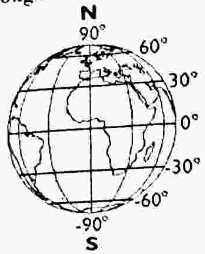
	Lunar Eclipse	Solar Eclipse
Health risk:	Safe to look at moon during eclipse	Retina gets damaged if Sun seen directly
Position of Earth and Moon:	Earth lies between the Sun and Moon	Moon lies between Sun and Earth
Types:	Penumbral, partial, total or horizontal	Total, annular, hybrid, partial
Occurrence:	At night	During day time

Frequency of occurrence:	Twice a year or more	A few every year, total being less frequent
Visibility:	Moon completely obscured, visible partially or in an orangish hue –visible from all night time places	Sun gets blocked by moon – eclipse visible only in some areas
Duration:	A few hours	Usually a few minutes

Latitude *and* Longitude



Longitude



Latitude

Latitude

Imaginary lines running horizontally around the globe. Also called parallels, latitude lines are equidistant from each other. Each degree of latitude is about 69 miles (110 km) apart. Zero degrees (0°) latitude is the equator, the widest circumference of the globe. Latitude is measured from 0° to 90° north and 0° to 90° south—90° north is the North Pole and 90° south is the South Pole.

Longitude

Imaginary lines, also called meridians, running vertically around the globe. Unlike latitude lines, longitude lines are not parallel. Meridians meet at the poles and are widest apart at the equator. Zero degrees longitude (0°) is called the prime meridian. The degrees of longitude run 180° east and 180° west from the prime meridian.

Difference *between* Latitude *and* Longitude

	Latitude	Longitude
Direction	East-west, parallel to the equator	North-south; converging at the poles and widest at the equator
Parallel lines:	Yes	No
Range:	0 to 90° North and South	0 to 180° East and West
Denoted by:	Greek letter phi (Φ)	Greek letter lambda (λ)
Hemisphere:	All locations along a common latitude fall in the same hemisphere of the earth (northern or southern)	Locations along a common longitude may be in different hemispheres.
Denotes distance from:	equator (north or south)	Prime Meridian (east or west)
Time zone:	Locations that share the same latitude do not necessarily fall into the same time zone	All locations on the same longitude fall in the same time zone
Number of lines:	180	360
Notable lines:	Equator, Tropic of Cancer, Tropic of Capricorn	Greenwich Meridian
Applications:	Classifying temperature zones	Classifying time zones

Equator

Zero degrees latitude. The Sun is directly overhead the equator at noon on the two equinoxes (March and Sept. 20 or 21). The equator divides the globe into the Northern and Southern hemispheres. The equator appears halfway between the North and South poles, at the widest circumference of the globe. It is 24,901.55 miles (40,075.16 km) long.

Prime meridian

Zero degrees longitude (0°). The prime meridian runs through the Royal Greenwich Observatory in Greenwich, England (the location was established in 1884 by international agreement). The prime meridian divides the globe into the Western and Eastern hemispheres. The Earth's time zones are measured from the prime meridian. The time at 0° is called Universal Time (UT) or Greenwich Mean Time (GMT). With the Greenwich meridian as the starting point, each 15° east and west marks a new time zone. The 24 time zones extend east and west around the globe for 180° to the International Date Line. When it is noon along the prime meridian, it is midnight along the International Date Line.

Tropic of Cancer

Tropic of Cancer, parallel of latitude at 23°30− north of the equator; it is the northern boundary of the tropics. This parallel marks the farthest point north at which the sun can be seen directly overhead at noon; north of the parallel the sun appears less than 90° from the southern horizon at any day of the year. The sun reaches its vertical position over the Tropic of Cancer at about June 22, the summer solstice in the Northern Hemisphere. When the Tropic of Cancer was named, the sun was in the constellation Cancer at the time of the summer solstice

Motions *of the* Earth

Q: Briefly explain what effects are produced due to Rotation & Revolution of Earth (CSS-2017)

The Earth is constantly in motion, revolving around the Sun and rotating on its axis. These motions account for many of the phenomenon we see as normal occurrences: night and day, changing of the seasons, and different climates in different regions. With a globe ball properly mounted and rotating on its axis, the movements of the Earth around the Sun may be illustrated accurately.

Rotation

The Earth spins on its axis from West to East (counter-clockwise). It takes the Earth 23 hours, 56 minutes, and 4.09 seconds to complete one full turn. Day and night are produced by the rotation of the Earth. The speed of rotation at any point upon the equator is at the rate of approximately 1,038 miles per hour, decreasing to zero at the poles.

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Effects *of* Earth's Rotation

1. **Temperature:** As the Earth spins around, the sun is evenly shining on all parts of the earth. This creates an exact temperature on Earth at the same latitude. Other planets such as Venus that have the same rate of spin as its revolution. This makes it so that it is extremely hot on one side of Venus and very cold on the other side since the sun only shines on one side of the planet.
2. **Coriolis Effect:** The Coriolis Effect is responsible for the rotation of cyclones, wind, and currents because of this, winds rotate counter clockwise in the Northern Hemisphere and clockwise in the Southern hemisphere. If someone were to launch something into the atmosphere for say a rocket, the Earth might rotate and the rocket would land that many degrees in the direction earth rotated away from the primary target.
3. **The Foucault pendulum:** As the Earth turns, the pendulum that is suspended above the floor swings freely. Since the Earth is turning sand or dominos are put under the pendulum to track its progress. As the earth turns the floor moves beneath the pendulum eventually causing a domino to get knocked over or sand to get scraped in a new place. This proved the rotation of Earth and the Coriolis effect.
4. **Night and Day:** While it seems like the sky moves above you it's actually the Earth moving. As the Earth rotates the Sun Shines on all parts of the earth except for one of the poles. While Earth is moving the Sun will eventually stop shining on one part of it since the Earth is turned away. This is what makes night.
5. **The direction of the sunrise and sunset:** The Earth rotates counterclockwise, if viewed form the North Pole. The rotation causes us to see the Sun rise in the east and set in the west.

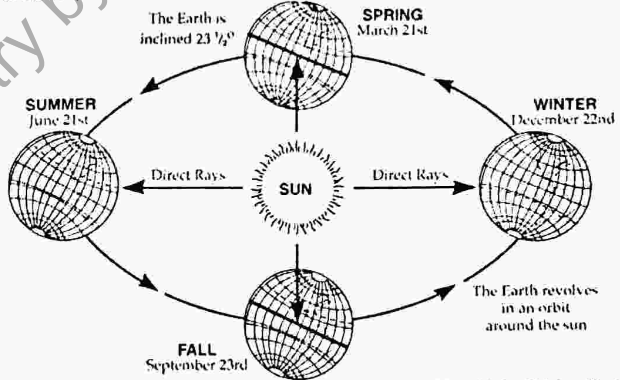
Revolution:

While the Earth is spinning on its axis, it is revolving around the Sun in a counter-clockwise direction. It takes the Earth one full year to complete one full revolution around the Sun. This path is known as the Earth's orbit. It is very near a circle. The mean distance of the Earth from the Sun is about 93 milling miles and the distance varies by 3 million miles, forming a slightly oval path. The revolution of the Earth around the Sun traverse a distance of 595 million miles in 365 days, 6 hours, 9

minutes and 9.5 seconds. This means a speed of 18 miles a second (or 66,000 miles per hour) while at the same time rotating once each twenty-four hours.

The Seasons

The seasons occur because the axis on which Earth turns is tilted with respect to the plane of Earth's orbit around the Sun. Earth's tilt causes the North Pole to be tilted toward the Sun for half of the year, and the South Pole to be tilted toward the Sun for the other half of the year. The hemisphere that is tilted toward the Sun has a longer day, receives more of the Sun's rays, and receives the Sun's rays more directly than the hemisphere tilted away from the Sun. When it is summer in the Northern Hemisphere, this hemisphere is tilted toward the Sun; this corresponds to winter in the Southern Hemisphere, when the Southern Hemisphere is tilted away from the Sun. If Earth's axis was not tilted, each night and day everywhere on Earth would always be 12 hours long and there would be no seasons. The axis of the planet Mars is also tilted with respect to the plane of Mars's orbit around the Sun, so Mars experiences seasons much like those of Earth



The seasons have an unequal number of days because Earth's orbit is slightly elliptical, or oval shaped, and the Sun is not exactly at the center of the orbit. Earth moves slightly faster when it is close to the Sun than when it is farther away, so the seasons that occur when Earth is close to the Sun pass more quickly. Earth is closest to the Sun in January and farthest away in July, so the summer is longer than the winter in the Northern Hemisphere. In the Southern Hemisphere, the winter is longer than the summer.

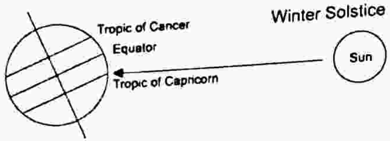
Solstices

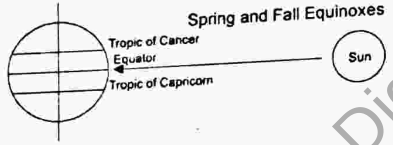
At solstice , the *day and night* are of *unequal length* A solstice is an astronomical event that occurs twice each year as the Sun reaches its highest or lowest excursion relative to the celestial equator on the celestial sphere. Solstice is derived from two Latin words: "sol" meaning sun, and "sistere" to cause to stand still. The Sun is said to be at a solstice when the difference between the distances from each pole to the Sun is at its greatest. The solstices usually occur on December 21 or 22 and June 21 or 22. In December, the South Pole is tilted farther toward the Sun than it is at any other time of the year and the North Pole is tilted farther away from the Sun; the Southern Hemisphere has its summer solstice and the Northern Hemisphere has its winter solstice. In June, during the Southern Hemisphere's winter solstice and the Northern Hemisphere's summer solstice, the North Pole is at its most direct tilt toward the Sun, and the South Pole tilts away from the Sun. The hemisphere most tilted toward the Sun on the solstice experiences its longest day of sunlight and its shortest night. The other hemisphere experiences its shortest day of sunlight and its longest night.

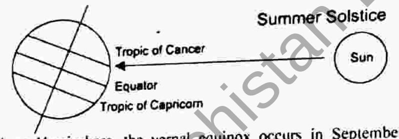
Equinox

"Equinox" means "equal night" in Latin. But even if the name suggests it and it's widely accepted, it isn't entirely true that day and night are exactly the same on the equinox all over the world only nearly.

In late March and late September both hemispheres are the same distance from the Sun and the Sun is said to be at an equinox. The Northern Hemisphere's vernal equinox usually occurs on March 20 or 21 and marks the beginning of spring. The Northern Hemisphere's autumnal equinox usually occurs on September 22 or 23 and marks the beginning of autumn.







In the Southern Hemisphere, the vernal equinox occurs in September and the autumnal equinox occurs in March. At the equinoxes, the Sun appears to be directly over Earth's equator. The lengths of day and night are then equal over almost all Earth, except at the poles. At the North Pole and South Pole, Earth's atmosphere bends the Sun's rays enough to make the Sun visible throughout the day and night, even during the 12 hours the Sun is below the horizon.

The changes in temperature and in the length of daylight that accompany the seasons differ greatly at different latitudes. At the poles, summer is three months of daylight and winter is three months of darkness. Near the equator, however, days and nights remain about 12 hours long throughout the year. The Arctic and Antarctic circles, at latitude 66°30' north and 66°30' south respectively, mark the farthest points from the poles at which there can be 24 hours of daylight or 24

hours of darkness. Midway between the poles and the equator, the length of daylight varies from about 8 hours in winter to about 16 hours in summer.

The Length of day and Temperature

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Difference *between* Rotation of Earth *and* Revolution of Earth

Rotation	Revolution
Rotation means "to spin." This is the cause of day and night. Earth rotates on its axis (an imaginary line running through the center of the Earth from the North Pole to the South Pole)	Revolution means "to go around something." This is the cause of four seasons. A synonym for revolution is orbit. (*revolution = orbit*)
The Earth rotates counterclockwise	The Earth revolves (*goes around*) the sun counterclockwise.
Earth completes 1 rotation (spin) every 24 hours..	It takes Earth 365 days (or 1 year) to make one complete revolution around the sun.
Day and night are caused by Earth's rotation (spin) on its axis. When ½ of the Earth is facing the sun it is DAY. When ½ of the Earth is facing away from the sun it is NIGHT.	Earth's seasons are caused by 1) Earth's titled axis and 2) Earth's revolution (orbit) around the sun. When the Northern Hemisphere is tilted toward the sun we have summer. When the Northern Hemisphere is titled away from the sun we have winter.

In brief: The basic difference between the two movements is the nature of the movement. The rotation means to circle around one's own axis while the revolution means to circle around any other object. The second difference is the velocity of the objects. The velocity of the object which rotates can be different from the object that revolves. The revolution and rotation co-exist in space while they can also be seen differently. Their co-existence is the reason why we see our earth as stationary object. The rotation is the movement that covers lower distance than revolution. For example, earth completes its rotation in almost 30 days, while the same earth completes its revolution in 365 days.

What is weather?

Weather describes the condition of the atmosphere over a short period of time e.g. from day to day or week to week, while climate describes average conditions over a longer period of time. Step outside and you experience many facets of weather. Humidity, air temperature and pressure, wind speed and direction, cloud cover and type, and the amount and form of precipitation are all atmospheric characteristics of the momentary conditions we call weather.

The sun is ultimately responsible for the weather. Its rays are absorbed differently by land and water surfaces (*equal amounts of solar radiation heat the ground more quickly than they do water*). Differential warming, in turn, causes variations in the temperature and pressure of overlying air masses.

As an air mass warms, it becomes lighter and rises higher into the atmosphere. As an air mass cools, it becomes heavier and sinks. Pressure differences between masses of air generate winds, which tend to blow from high-pressure areas to areas of low pressure. Fast-moving, upper atmosphere winds known as jet streams help move weather systems around the world.

What is climate?

It has been said that "climate is what you expect; weather is what you get". In other words, you can expect snow in Pakistan in January, but you may or may not get it on a particular day.

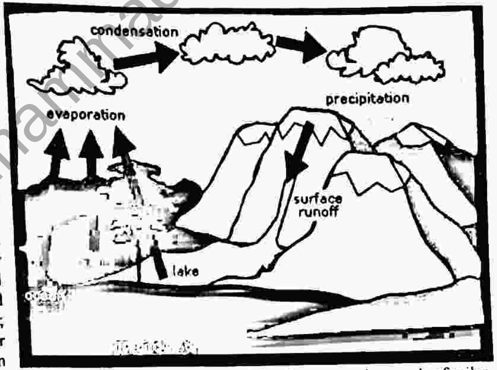
The climate of an area or country is known through the average weather over a long period of time. If an area has more dry days throughout the year than wet days, it would be described as a dry climate; a place which has more cold days than hot days would make it known to have a cold climate.

Factors that Influence Weather

There are many factor that influence weather, many of which we cannot see.

The Water Cycle

As the sun warms the surface of the Earth, water rises in the form of water vapor from lakes, rivers, oceans, plants, the ground, and other sources. This process is called evaporation.



Water vapor provides the moisture that forms clouds; it eventually returns to Earth in the form of precipitation, and the cycle continues.

Air Masses

When air hovers for a while over a surface area with uniform humidity and temperature, it takes on the characteristics of the area below. For example, an air mass over the tropical Atlantic Ocean would become warm and humid; an air mass over the winter snow and ice of northern Canada would become cold and dry. These massive volumes of air often cover thousands of miles and reach to the stratosphere. Overtime, mid-latitude cyclonic storms and global wind patterns move them to locations far from their source regions.

What happens when 2 air masses meet? The cold air pushes the hot air upwards, when going up the temperature drops and the air can't hold as much water when it is warm, so the cold water molecules condense and form clouds.

Jet Stream

A jet stream is the name given to the area of air above where two air masses of different temperature converge e.g. a cold front meeting a warm front. The greater the temperature difference between the air masses, the greater the air pressure difference, and the faster the wind blows in the jet stream. This river of air has wind speeds which often exceed 100 mph, and sometimes over 200 mph. Jet streams more commonly form in the winter, when there is a greater difference between the temperature of the cold continental air masses and warm oceanic air masses.

This meandering current of high-speed wind, a jet stream is usually found around five to ten miles above Earth's surface.

Weather Fronts

The transition zone between two air masses of different humidity and temperature is called a front. Along a cold front, cold air displaces warm air; along a warm front, warm air displaces cold air. When neither air mass displaces the other, a stationary front develops. Towering clouds and intense storms may form along cold fronts, while widespread clouds and rain, snow, sleet, or drizzle may accompany warm fronts.

Elements of Weather

The elements of weather include *temperature, humidity, cloudiness, precipitation, wind,* and *pressure*. These elements are organized into various weather systems, such as monsoons, areas of high and low pressure, thunderstorms, and tornadoes. All weather systems have well-defined cycles and structural features and are governed by the laws of heat and motion. These conditions are studied in meteorology, the science of weather and weather forecasting.

Weather differs from climate, which is the weather that a particular region experiences over a long period of time. Climate includes the averages and variations of all weather elements.

Hot and Cold Weather Facts

Al'Aziziyah in Libya has the highest recorded temperature on earth at a sweltering 58°C on the 13th Sept, 1922.

The lowest ever recorded world temperature was at Vostok Station, Antarctica on the 21 July 1983 at a bitter -89.6°C.

1) Temperature

Temperature is a measure of the degree of hotness of the air. Three different scales are used for measuring temperature. Scientists use the Kelvin, or absolute, scale and the Celsius, or centigrade, scale. Most nations use the Celsius scale, although the United States continues to use the Fahrenheit scale.

Temperature on earth averages 15° C (59° F) at sea level but varies according to latitude, elevation, season, and time of day, ranging from a record high of 58° C (140° F) to a record low of -88° C (-130° F). Temperature is generally highest in the Tropics and lowest near the poles. Each day it is usually warmest during midafternoon and coldest around dawn.

Wet and Dry Facts about Weather

Mawsynram in India is noted as being the wettest place on earth is with over 11 meters of rain falling every year.

In contrast, Antofagasta in Chile is the driest place on the planet getting less than 0.1mm per year, and with many years having no rainfall whatsoever

Seasonal variations of temperature are generally more pronounced at higher latitudes. Along the equator, all months are equally warm, but away from the equator, it is generally warmest about a month after the summer solstice (around June 21 in the northern hemisphere and around December 21 in the southern hemisphere) and coldest about a month after the winter solstice (around December 21 in the northern hemisphere and around June 21 in the southern hemisphere). Temperature can change abruptly when fronts (boundaries between two air masses with different temperatures or densities) or thunderstorms pass overhead.

Temperature decreases with increasing elevation at an average rate of about 6.5° C per km (about 19° F per mi). As a result, temperatures in the mountains are generally much lower than at sea level.

Temperature continues to decrease throughout the atmosphere's lowest layer, the troposphere, where almost all weather occurs.

Sunny Facts

Yuma in the US state of Arizona has over 4,000 hours of sunshine per year - making it the sunniest place on the planet!

The South Pole is the least sunny place - only 182 days a year get sunshine.

2) Humidity

Humidity is a measure of the amount of water vapor in the air. The air's capacity to hold vapor is limited but increases dramatically as the air warms, roughly doubling for each temperature increase of 10° C (18° F). There are several different measures of humidity. The specific humidity is the fraction of the mass of air that consists of water vapor, usually given as parts per thousand. Even the warmest, most humid air seldom has a specific humidity greater than 20 parts per thousand. The most common measure of humidity is the relative humidity, or the amount of vapor in the air divided by the air's vapor-holding capacity at that temperature. If the amount of water vapor in the air remains the same, the relative humidity decreases as the air is heated and increases as the air is cooled. As a result, relative humidity is usually highest around dawn, when the temperature is lowest, and lowest in midafternoon, when the temperature is highest.

Windy Facts

The windiest place on earth is Commonwealth Bay, Antarctica where winds of 200mph have been recorded.

The strongest ever recorded wind was on Mt Washington, New Hampshire, USA at an amazing 231mph.

3) Cloudiness

Most clouds and almost all precipitation are produced by the cooling of air as it rises. When air temperature is reduced, excess water vapor in the air condenses into liquid droplets or ice crystals to form clouds or fog. A cloud can take any of several different forms—including cumulus, cirrus, and stratus—reflecting the pattern of air motions that formed it. Fluffy cumulus clouds form from rising masses of air, called thermals. A cumulus cloud often has a flat base, corresponding to the level at which the water vapor first condenses. If a cumulus cloud grows large, it transforms into a cumulonimbus cloud or a thunderstorm. Fibrous cirrus clouds consist of trails of falling ice crystals twisted by the winds. Cirrus clouds usually form high in the troposphere, and their crystals almost never reach the ground. Stratus clouds form when an entire layer of air cools or ascends obliquely. A stratus cloud often extends for hundreds of miles.

Fog is a cloud that touches the ground. In dense fogs, the visibility may drop below 50 m (55 yd). Fog occurs most frequently when the earth's surface is much colder than the air directly above it, such as around dawn and over cold ocean currents. *Fog* is thickened and acidified when the air is filled with sulfur-laden soot particles produced by the burning of coal.

4) Precipitation

Precipitation is produced when the droplets and crystals in clouds grow large enough to fall to the ground. Clouds do not usually produce precipitation until they are more than 1 km (0.6 mi) thick. Precipitation takes a variety of forms, including rain, drizzle, freezing rain, snow, hail, and ice pellets, or sleet. Raindrops have diameters larger than 0.5 mm (0.02 in), whereas drizzle drops are smaller. Few raindrops are larger than about 6 mm (about 0.2 in), because such large drops are unstable and break up easily. Ice pellets are raindrops that have frozen in midair. Freezing rain is rain that freezes on contact with any surface. It often produces a layer of ice that can be very slippery.

Stormy Weather Facts

Nearly 2,000 thunderstorm cells are estimated over the planet at any given time.

The U.S. has over 100,000 thunderstorms every year, with over 16 million taking place across the world in a year.

9 out of 10 lightning bolts strike land rather than oceans.

A storm named John was the Longest-lasting Pacific tropical storm continuing for 31 days. As it crossed the dateline twice, it changed status from a hurricane to a typhoon and back to a hurricane "Ginger", was the longest-lasting Atlantic tropical storm, which spun around the open ocean for 28 days in 1971.

Precipitation amounts are usually given in terms of depth. A well-developed winter storm can produce 10 to 30 mm (0.4 to 1.2 in) of rain over a large area in 12 to 24 hours. An intense thunderstorm may produce more than 20 mm (0.8 in) of rain in 10 minutes and cause flash floods

(floods in which the water rises suddenly). Hurricanes sometimes produce over 250 mm (10 in) of rain and lead to extensive flooding.

5) Wind

Wind is the horizontal movement of air. It is named for the direction from which it comes—for example, a north wind comes from the north. In most places near the ground, the wind speed averages from 8 to 24 km/h (from 5 to 15 mph), but it can be much higher during intense storms. Wind speeds in hurricanes and typhoons exceed 120 km/h (75 mph) near the storm's center and may approach 320 km/h (200 mph). The highest wind speeds at the surface of the earth—as high as 480 km/h (300 mph)—occur in tornadoes. Except for these storms, wind speed usually increases with height to the top of the troposphere.

Snowy Weather Facts

The world's largest snowflake was recorded in the Guinness Book of Records, at 38 cm wide and 20 cm thick. The snow flake fell at Fort Keogh, Montana, USA on 28 January 1887.

The greatest snowfall recorded was on Mt Rainier, Washington State, USA - Over 30metres fell during the winter of 1972.

6) Pressure

Pressure plays a vital role in all weather systems. Pressure is the force of the air on a given surface divided by the area of that surface. In most weather systems the air pressure is equal to the weight of the air column divided by the area of the column. Pressure decreases rapidly with height, halving about every 5.5 km (3.4 mi).

Sea-level pressure varies by only a few percent. Large regions in the atmosphere that have higher pressure than the surroundings are called high-pressure areas. Regions with lower pressure than the surroundings are called low-pressure areas. Most storms occur in low-pressure areas. Rapidly falling pressure usually means a storm is approaching, whereas rapidly rising pressure usually indicates that skies will clear.

Weird Weather Facts

On 14th April, 1986 Bangladesh was hit by the biggest hail stones ever recorded - weighing in at over 1kg each - killing 92 people.

Scales of Weather

Weather systems occur on a wide range of scales. Monsoons occur on a global scale and are among the largest weather systems, extending for thousands of miles. Thunderstorms are much smaller, typically 10 to 20 km (6 to 12 mi) across. Tornadoes, which extend from the bases of thunderstorms, range from less than 50 m (55 yd) across to as much as 2 km (1.2 mi) across.

The vertical scale of weather systems is much more limited. Because pressure decreases so rapidly with height and because temperature stops decreasing in the stratosphere, weather systems are confined to the troposphere. Only the tallest thunderstorms reach the stratosphere, which is otherwise almost always clear.

Causes of Weather

All weather is due to heating from the sun. The sun emits energy at an almost constant rate, but a region receives more heat when the sun is higher in the sky and when there are more hours of sunlight in a day. The high sun of the Tropics makes this area much warmer than the poles, and in summer the high sun and long days make the region much warmer than in winter. In the northern hemisphere, the sun climbs high in the sky and the days are long in summer, around July, when the northern end of the earth's axis is tilted toward the sun. At the same time, it is winter in the southern hemisphere. The southern end of the earth's axis is tilted away from the sun, so the sun is low in the sky and the days are short.

The temperature differences produced by inequalities in heating cause differences in air density and pressure that propel the winds. Vertical air motions are propelled by buoyancy: A region of air that is warmer and less dense than the surroundings is buoyant and rises. Air is also forced from regions of higher pressure to regions of lower pressure. Once the air begins moving, it is deflected by the Coriolis force, which results from the earth's rotation. The Coriolis force deflects the wind and all moving objects toward their right in the northern hemisphere and toward their left in the southern hemisphere. It is so gentle that it has little effect on small-scale winds that last less than a few hours, but it has a profound effect on winds that blow for many hours and move over large distances.

Weather Systems

Cloud patterns indicate the presence of weather systems, which produce most of the weather we are familiar with: rain, heat waves, cold snaps, humidity, and cloudiness. Weather systems are simply the movement of warm and cold air across the globe. These movements are known as low-pressure systems and high-pressure systems.

High-pressure systems are rotating masses of cool, dry air. High-pressure systems keep moisture from rising into the atmosphere and forming clouds. Therefore, they are usually associated with clear skies. On the other hand, low-pressure systems are rotating masses of warm, moist air. They usually bring storms and high winds.

High-pressure and low-pressure systems continually pass through the mid-latitudes, or areas of the Earth about halfway between the Equator and the poles, so weather there is constantly changing.

A weather map is filled with symbols indicating different types of weather systems. Spirals, for instance, are cyclones or hurricanes, and thick lines are fronts. Cyclones have a spiral shape because they are composed of air that swirls in a circular pattern.

A front is a narrow zone across which temperature, humidity, and wind change abruptly. A front exists at the boundary between two air masses. An air mass is a large volume of air that is mostly the same temperature and has mostly the same humidity.

When a warm air mass moves into the place of a cold air mass, the boundary between them is called a warm front. On a weather map, a warm front is shown as a red band with half-circles pointing in the direction the air is moving.

When a cold air mass takes the place of a warm air mass, the boundary between them is called a cold front. On a weather map, a cold front is shown as a blue band with triangles pointing in the direction the air is moving.

A stationary front develops when warm air and cold air meet and the boundary between the two does not move. On a weather map, a stationary front is shown as alternating red half-circles and blue triangles, pointing in opposite directions.

When a cold front overtakes a warm front, the new front is called an occluded front. On a weather map, an occluded front is shown as a purple band with half-circles and triangles pointing in the direction the air is moving. Cold fronts are able to overtake warm fronts because they move faster.

Weather Forecasting

Since the early 20th century, great strides have been made in weather prediction, largely as a result of computer development but also because of instrumentation such as satellites and radar. Weather data from around the world are collected by the World Meteorological Organization, the National Weather Service, and other agencies and entered into computer models that apply the laws of motion and of the conservation of energy and mass to produce forecasts. In some cases, these forecasts have provided warning of major storms as much as a week in advance. However, because the behavior of weather systems is chaotic, it is impossible to forecast the details of weather more than about two weeks in advance.

Intense small-scale storms, such as thunderstorms and tornadoes, are much more difficult to forecast than are larger weather systems. In areas in which thunderstorms are common, general forecasts can be made several days in advance, but the exact time and location of the storms, as well as of flash floods and tornadoes, can only be forecast about an hour in advance. (For a discussion of weather forecasting methods and technologies, see Meteorology.)

Weather Modification

Human beings can change weather and climate. Water-droplet clouds with tops colder than about -5° C (about 23° F) can be made to produce rain by seeding them with substances such as silver iodide. Cloud seeding causes ice crystals to form and grow large enough to fall out of a cloud. However, although cloud seeding has been proven effective in individual clouds, its effect over large areas is still unproven.

Weather near the ground is routinely modified for agricultural purposes. For example, soil is darkened to raise its temperature, and fans are turned on during clear, cold nights to stir warmer air down to the ground and help prevent frost damage.

Human activities have also produced inadvertent effects on weather and climate. Adding gases such as carbon dioxide and methane to the atmosphere has increased the greenhouse effect and contributed to global warming by raising the mean temperature of the earth by about 0.5° C (about 0.9° F) since the beginning of the 20th century. More recently, chlorofluorocarbons (CFCs), which are used as refrigerants and in aerosol propellants, have been released into the atmosphere, reducing the amount of ozone worldwide and causing a thinning of the ozone layer over Antarctica each spring (around October).

Factors that Influence Climate

There are lots of factors that influence our climate

Elevation or Altitude effect climate

Normally, climatic conditions become colder as altitude increases. "Life zones" on a high mountain reflect the changes, plants at the base are the same as those in surrounding countryside, but no trees at all can grow above the timberline. Snow crowns the highest elevations.

Prevailing global wind patterns

There are 3 major wind patterns found in the Northern Hemisphere and also 3 in the Southern Hemisphere. These are average conditions and do not essentially reveal conditions on a particular day. As seasons change, the wind patterns shift north or south. So does the intertropical convergence zone, which moves back and forth across the Equator. Sailors called this zone the doldrums because its winds are normally weak.

Latitude and angles of the sun's rays

As the Earth circles the sun, the tilt of its axis causes changes in the angle of which sun's rays contact the earth and hence changes the daylight hours at different latitudes. Polar Regions experience the greatest variation, with long periods of limited or no sunlight in winter and up to 24 hours of daylight in the summer.

Topography

The Topography of an area can greatly influence our climate. Mountain ranges are natural barriers to air movement. In California, winds off the Pacific ocean carry moisture-laden

air toward the coast. The Coastal Range allows for some condensation and light precipitation. Inland, the taller Sierra Nevada range rings more significant precipitation in the air. On the western slopes of the Sierra Nevada, sinking air warms from compression, clouds evaporate, and dry conditions prevail.

Effects of Geography

The position of a town, city or place and its distance from mountains and substantial areas of water help determine its prevailing wind patterns and what types of air masses affect it. Coastal areas may enjoy refreshing breezes in summer, when cooler ocean air moves ashore. Places south and east of the Great Lakes can expect "lake effect" snow in winter, when cold air travels over relatively warmer waters.

In spring and summer, people in Tornado Alley in the central United States watch for thunderstorms, these storms are caused where three types of air masses frequently converge: cold and dry from the north, warm and dry from the southwest, and warm and moist from the Gulf of Mexico - these colliding air masses often generate tornado storms.

Surface of the Earth

Just look at any globe or a world map showing land cover, and you will see another important factor which has a influence on climate: the surface of the Earth. The amount of sunlight that is absorbed or reflected by the surface determines how much atmospheric heating occurs. Darker areas, such as heavily vegetated regions, tend to be good absorbers; lighter areas, such as snow and ice-covered regions, tend to be good reflectors. The ocean absorbs and loses heat more slowly than land. Its waters gradually release heat into the atmosphere, which then distributes heat around the globe.

Climate change over time

and warm periods punctuate Earth's long history. Some were fairly short; others spanned hundreds of thousands of years. In some cold periods, glaciers grew and spread over large regions. In subsequent warm periods, the ice retreated. Each period profoundly affected plant and animal life. The most recent cool period, often called the "Little Ice Age," ended in Western Europe around 1850.

Since the turn of the 20th century, temperatures have been rising steadily throughout the world. But it is not yet clear how much of this global warming is due to natural causes and how much derives from human activities, such as the burning of fossil fuels and the clearing of forests.

Climates around the world

World climates

Climates around the world vary greatly and do not easily fit into precise climatic categories. Large variations in climate occur across relatively small distances. However, it is useful to split different weather types into a number of categories according to describable weather patterns. Climate zones can be categorized in a number of different ways but commonly used climate zones include: temperate, polar, arid, Mediterranean, tropical and mountainous.

A number of different factors affect the climate in each zone. These include:

- **Latitude** -areas closest to the equator are generally warmer. This is because the Sun's rays are most intense when they strike the Earth's surface at right angles, ie when the sun is directly overhead. At the Polar Regions, solar radiation strikes the Earth at a much shallower angle. This 'projection effect' at the Poles means that solar radiation is cast over a greater surface area. This is the main reason why Polar Regions are colder.

- **Wind direction** -winds blowing from warmer climates will increase temperatures whilst ice sheets and glaciers have very cold air above them and wind blowing away from these will be especially cold.
- **Mountains** -these can impact on levels of rainfall.
- **Aspect** -slopes facing the sun are warmest. South-facing slopes in the northern hemisphere are usually warm but slopes facing north in the southern hemisphere are warmest.
- **Closeness to the sea** -this is because the sea cannot warm up or cool down as much as or as quickly as land. Therefore coastal areas don't experience extremes in temperature but areas well away from the influences of the sea can experience extreme temperature variations.

Temperate

Temperate climate zones lie between the tropics and the polar circles. Countries with temperate climates include the UK, New Zealand, eastern Asia and southern Chile as well as much of northwest Europe and coastal areas of North America. In these regions the changes between summer and winter are not extreme but temperate climates can have very unpredictable weather. Temperate zones cover about 7% of the world's land surface but are by far the most popular areas in which to live-providing a home to around four-tenths of the Earth's population. This is largely due to the mildness of the climate, the plentiful supply of rain and generally very fertile soils. The majority of the land in temperate zones has been cleared of its natural forest vegetation to make way for more intensive farming methods.

Deciduous trees such as the oak and the beech are the most common types of tree found in these regions. These have formed a protective mechanism against the effects of cold winters by shedding their leaves.

Polar

Polar climates are located in the high latitudes of the world and are marked by a permanent covering of snow and ice throughout the year. The north Polar Regions include the Arctic Ocean, the Greenland continent and much of Northern Canada and Northern Siberia while the vast mountainous Antarctic continent dominates the southern polar region.

The high latitude of the Polar Regions means that the sun's warming effect is diminished and this results in the temperatures rarely reaching above freezing. In winter, the Polar Regions are covered in darkness and temperatures can fall as low as -80°C in the Antarctic and -50°C in the Arctic. The summer temperatures can reach 10°C in the Antarctic and up to 30°C in some areas of the Arctic. The average annual rainfall in Polar Regions is very low -often less than 250 mm. This makes these regions as dry as the hot deserts of the sub-tropics.

Arid

Arid climates are normally hot and very dry, so they have a severe lack of water. Deserts fall into this category. The Sahara Desert along with Saudi Arabia and large parts of Iran and Iraq all have arid climates. The Atacama Desert in South America is one of the driest places on earth and some parts of this desert haven't seen any rain for at least 400 years. And the Gobi Desert in Northern China is characterized by harsh conditions and temperature extremes which can pusl most living organisms to their limits.

There are two seasons in arid climates -winter and summer. The desert's dryness means there is no humidity and so the skies are clear.

They have big daily and seasonal temperature ranges, with high daytime temperatures in summer up to a very hot 50°C, and low night-time temperatures in winter down to a freezing cold 0°C or in the Gobi much lower.

When rains do fall, they can cause flash floods. Very strong winds can create desert sand or dust Storms

Tropical

The zone known as the Tropics lies between the Tropic of Cancer at 23.5° N latitude and the Tropic of Capricorn at 23.5° S latitude. Tropical climates are often associated with the rich variety of plants, insects and animals found in jungles and rain forests.

Much of the equatorial belt within the tropical climate zone experiences hot and humid weather. There is abundant sunshine but heavy rainfall, and thunderstorms can occur almost every day. Areas with tropical climates include the Amazon Basin in Brazil, the Congo Basin in West Africa, Malaysia, southern Vietnam and Indonesia.

Temperatures

Temperatures in the tropics rarely exceed 35°C because a large proportion of the sun's heat is used up in evaporation and rain formation. A daytime maximum of 32°C is common, with night-time temperatures falling to about 22°C. Temperatures in the tropics remain constantly high throughout the year, with as little as 2°C separating the highest noon temperature from the lowest throughout the year.

Seasons

The seasons, as far as they exist, are distinguished by changes in rainfall and cloud cover rather than by periods of hot or cooler weather. On the equator there tend to be two wet and two dry seasons but as you move away from the equator the two rainy seasons merge into one, and the climate becomes more monsoonal, with one wet season and one dry season.

Mountain

Mountains have a significant effect on weather and climate at both a local and a global level. Mountains create their own climate no matter where they are located and tend to be much wetter than their surrounding areas. In the western highlands of Scotland, for example, the average annual rainfall is 4577 millimeters, while on the east coast of Scotland, rainfall can be as low as 550 millimeters.

This is because the Grampian and Cairngorm mountain ranges force moist air to rise and condense and fall as precipitation.

Sub-climates

The climates on mountains can vary greatly depending on altitude and aspect. For every 1000 meters you climb it is usually 6°C colder and high mountain ranges may be split into several sub-climate zones.

For instance, mountains in tropical climates may have foothills covered in rainforests but their upper slopes may be covered in pine forests. Above the tree line you may find alpine plants which can withstand the harsh conditions.

The highest slopes and peaks may be bare rock and covered in snow and ice. Examples of these types of mountain climates can be found in the Himalayas, the Rocky Mountains and the Andes. In Africa, only Mount Kenya, Kilimanjaro and the Rwenzori range are high enough to carry permanent snow.

Natural Hazards and Disasters

Earthquake

(CSS 1989, 1998, 2008, 2012)

Q: What is an earth quake? Discuss Richter scale in this context. What was the intensity of the earth quake in Pakistan dated 26 October 2015 and where was the locus? (CSS 2016)

Earthquake

Earthquake shaking of the Earth's surface caused by rapid movement of the Earth's rocky outer layer. Earthquakes occur when energy stored within the Earth, usually in the form of strain in rocks, suddenly releases. This energy is transmitted to the surface of the Earth by earthquake waves. The study of earthquakes and the waves they create is called Seismology (from the Greek *seismos*, "to shake"). Scientists who study earthquakes are called seismologists.

Anatomy of an Earthquake

Focus and Epicenter

The point within the Earth along the rupturing geological fault where an earthquake originates is called the focus, or hypocenter. The point on the Earth's surface directly above the focus is called the epicenter.

Seismologists know from observations that most earthquakes originate as shallow-focus earthquakes and most of them occur near plate boundaries—areas where the Earth's crustal plates move against each other. Other earthquakes, including deep-focus earthquakes, can originate in subduction zones, where one tectonic plate subducts, or moves under another plate.

Faults

Stress in the Earth's crust creates faults, resulting in earthquakes. The properties of an earthquake depend strongly on the type of fault slip, or movement along the fault, that causes the earthquake.

Waves

The sudden movement of rocks along a fault causes vibrations that transmit energy through the Earth in the form of waves. Waves that travel in the rocks below the surface of the Earth are called body waves, and there are two types of body waves: primary, or P, waves, and secondary, or S, waves. The S waves, also known as shearing waves, move the ground back and forth.

Earthquakes also contain surface waves that travel out from the epicenter along the surface of the Earth. Two types of these surface waves occur: Rayleigh waves, named after British physicist Lord Rayleigh, and Love waves, named after British geophysicist A. E. H. Love. Surface waves also cause damage to structures, as they shake the ground underneath the foundations of buildings and other structures.

Earthquake Causes (CSS 2008)

Most earthquakes are caused by the sudden slip along geologic faults. The faults slip because of movement of the Earth's tectonic plates. This concept is called the elastic rebound theory. The rocky tectonic plates move very slowly, floating on top of a weaker rocky layer. As the plates collide with each other or slide past each other, pressure builds up within the rocky crust. Earthquakes occur when pressure within the crust increases slowly over hundreds of years and finally exceeds the strength of the rocks. Earthquakes also occur when human activities, such as the filling of reservoirs, increase stress in the Earth's crust.

Richter Scale

The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Theories of Earthquakes

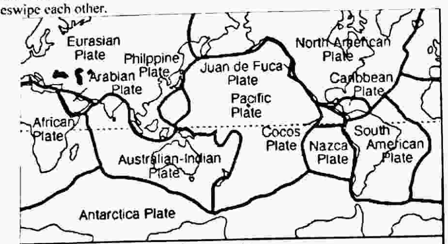
Plate Tectonics Theory

Plate tectonics is the theory that Earth's outer shell is divided into several plates that glide over the mantle, the rocky inner layer above the core. The plates act like a hard and rigid shell compared to Earth's mantle. This strong outer layer is called the lithosphere.

Developed from the 1950s through the 1970s, plate tectonics is the modern version of continental drift, a theory first proposed by scientist Alfred Wegener in 1912.

The theory states that Earth's outermost layer, the lithosphere, is broken into 7 large, rigid pieces called plates: the African, North American, South American, Eurasian, Australian, Antarctic, and Pacific plates. Several minor plates also exist, including the Arabian, Nazca, and Philippines plates.

The plates are all moving in different directions and at different speeds (from 2 cm to 10 cm at which your fingernails grow) in relationship to each other. The plates are moving around like cars in a demolition derby, which means they sometimes crash together, pull apart, or sideswipe each other.



Major tectonic plates of the world.

The place where the two plates meet is called a plate boundary. Boundaries have different names depending on how the two plates are moving in relationship to each other

- crashing: Convergent Boundaries.
- pulling apart: Divergent Boundaries.
- or sideswiping: Transform Boundaries

Volcanic Earthquake

Molten rock, called magma, is stored in reservoirs under volcanoes. As this magma moves upwards, it can fracture the rock it squeezes through, causing earthquakes, usually with magnitudes not much greater than 5.0. Sometimes the magma collects in a high level reservoir prior to a volcanic eruption and as it moves around it causes bursts of continuous vibration, called volcanic tremor. Because of these precursors, seismographs (earthquake recorders) are very useful for monitoring volcanoes to give warning of an impending eruption.

Foreshocks and Aftershocks

Foreshocks are smaller earthquakes that may occur in the same area as a larger earthquake that follows. They are caused by minor fracturing of rocks under stress prior to the main break that happens during the largest earthquake of the series, called the main shock. Foreshocks can start up to a year before the main shock

Aftershocks are smaller earthquakes that may occur after the main shock, in the same area. They are caused by the main shock area readjusting to the fault movement, and some may be the result of continuing movement along the same fault. The largest aftershocks are usually at least half a magnitude unit smaller than the mainshock and the aftershock sequence may continue for months or years after the main shock.

Earthquakes caused by the Isostatic Adjustment

As the crust re-adjusts to the lighter load (isostatic rebound to achieve equilibrium) it transfers stress to other parts of the crust. If there is a fault near enough to the new stresses, that can add enough stress to cause the fault(s) to move and that can produce an earthquake. This is not the major cause of earthquakes but New Madrid in the US may have some of that effect but don't quote me on that because there are other things going on to cause fault movement there. Very few things happen in isolation. Since this process happens over a great length of time, such earthquakes are more minor than

Fracking Causes Earthquakes

Two separate studies are providing insights into the earth-shaking consequences of the controversial gas extraction process known as fracking. Both studies confirm that processes linked to the extraction of oil and gas through hydraulic fracturing, or fracking, can trigger manmade earthquakes Fracking involves blasting water, sand and chemicals deep into the ground to fracture rock to obtain oil and natural gas. Energy companies are increasingly using the technique across Canada, where there is already regular seismic activity and an ever looming threat of various sized tremors. The U.S. Geological Survey is set to release its findings April 2012 that a "remarkable" increase of quakes in the U.S. midcontinent since 2001 is "almost certainly" the result of oil and gas production.

The intensity of the Earthquake in Pakistan (26 October 2015)

According to United States Geological Survey "The Quake was 196 km deep and centered 82 km south east of feyzabad in a remote area of Afghanistan in the Hindu Kush mountain range" and the intensity was 7.5. Meteorological Department of Pakistan said "the magnitude of earthquake was 8.1".

Most earthquakes are causally related to compressional or tensional stresses built up at the margins of the huge moving lithospheric plates that make up the earth's surface The immediate cause of most shallow earthquakes is the sudden release of stress along a fault, or fracture in the earth's crust, resulting in movement of the opposing blocks of rock past one another. These movements cause vibrations to pass through and around the earth in wave form, just as ripples are generated when a pebble is dropped into water. Volcanic eruptions, rock falls, landslides, and explosions can also cause a quake, but most of these are of only local extent. Shock waves from a powerful earthquake can trigger smaller earthquakes in a distant location hundreds of miles away if the geologic conditions are favorable.

Measurement of Earthquakes

The power of an earthquake is measured using a seismometer. A seismometer detects the vibrations caused by an earthquake. It plots these vibrations on a seismograph.

The strength, or magnitude, of an earthquake is measured using the Richter scale. The Richter scale is numbered 0-10.

Volcanoes

(CSS 1999, 2012)

A volcano is a place on the Earth's surface (or any other planet's or moon's surface) where molten rock, gases and pyroclastic debris erupt through the earth's crust. Volcanoes vary quite a bit in their structure - some are cracks in the earth's crust where lava erupts, and some are domes, shields, or mountain-like structures with a crater at the summit.

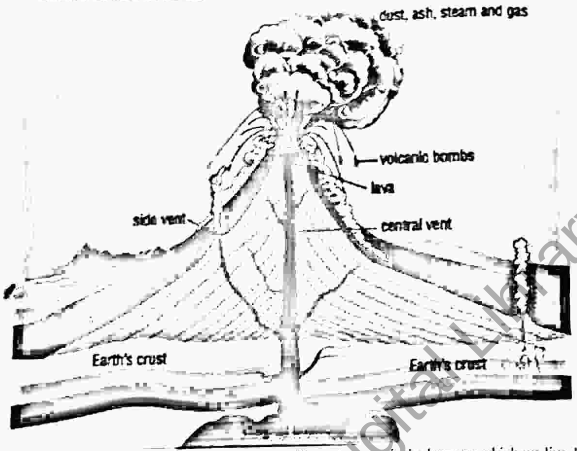
Magma is molten rock within the Earth's crust. When **magma** erupts through the earth's surface it is called **lava**. Lava can be thick and slow-moving or thin and fast-moving. Rock also comes from volcanoes in other forms, including ash (finely powdered rock that looks like dark smoke coming from the volcano), cinders (bits of fragmented lava), and pumice (light-weight rock that is full of air bubbles and is formed in explosive volcanic eruptions - this type of rock can float on water).

The Word Volcano:

The word volcano comes from the Roman god of fire, Vulcan. Vulcan was said to have had a forge (a place to melt and shape iron) on Vulcano, an active volcano on the Lipari Islands in Italy.

Why do volcanoes erupt?

Let us start with what the earth is made of:



- The earth is made up of three layer parts. The outer crust is the layer on which we live. It is estimated to be about 1800 miles deep. Then there is the mantle; and then the core (inner and outer core)
- The mantle is made up of molten material and gases. Molten materials are solids (like rock) that have turned into liquid because of extreme heat. The name for molten rock and other gases in the earth's mantle is Magma. Magma is liquid made up of many crystals, fragments and gases including oxygen, silicon, iron, aluminum, magnesium and manganese. When they cool off on the earth's surface, they turn into magmatic or igneous rocks.
- Whenever extreme pressure builds in the mantle, along fault lines (*openings or cracks in weak spots in the earth's crust*) an eruption is likely to happen next. During an eruption, molten materials (*soon to become lava*) gush out through spaces in the crust to the surface.

  ***NOTE:** Molten rock is called magma when it is inside the crust but once it gets to the surface of the earth it is called lava.*

- Eruptions can be in the form of lava fragments shooting into the atmosphere and forming thick clouds of lava. Some also flow slowly (non-violent) from the vent, flooding the area around it. Very fine particles of ash may also be discharged high into the stratosphere and further carried away by wind action.
- Fresh lava is believed to be about 2,200°F. It can be red hot as it shoots from the vent and turn into gray or black as it cools. Lava rich in silicon is like honey, and flows a lot more slowly from the vent. In other types, lava also comes in thick, pasty form.

DID YOU KNOW?

There are around 1510 'active' volcanoes in the world. Volcanologists disagree on what comes under the term 'active', but 1510 volcanoes have erupted in the last 10,000 years, which means they are active in the world of volcanoes. There are thought to be many more volcanoes on the sea bed

Types of Volcano

There are three main types of volcano. Scientists decide what type a volcano is examining the plate movements that have caused it to form.

- **Subduction volcanoes.** Subduction volcanoes occur where plates move towards each other and collide. The areas where this happens are called destructive plate margins, because the earth's crust is being destroyed. The diagrams on this page show that three main types of destructive plate margin, where subduction volcanoes are formed.
- **Rift volcanoes.** Where plates are moving apart, as in the middle of the Atlantic Ocean, magma rises through the gap between the separating plates and creates new rock. Here the volcanoes are known as rift volcanoes. There are more rift volcanoes than subduction volcanoes, but we hear far less about them. Most of them are hidden from view on the ocean floor, and they do not often threaten human life or property. Also, they usually erupt more gently than other types of volcano, with lava that oozes rather than explodes from inside them. Iceland, which straddles the Mid-Atlantic Ocean Ridge, and the Rift Valley of East Africa are two of the few places where rift volcanoes are found on land.
- **Hot-spot volcanoes.** Some volcanoes are found away from the edges of the plates. They are formed where rising plumes of magma force their way to the surface from deep within the mantle, a 'hot spot'. As the plate moves, the existing volcano is carried away from the hot spot and becomes extinct. The next time the pressure builds up, new magma erupts to form another volcano in its place. The best-known hot-spot volcanoes are in the Hawaiian Islands. The oldest in the west, such as Niihau and Kauai, contain extinct volcanoes, but the eastern islands of Maui and Hawaii itself still have active volcanoes.

Distribution of Volcanoes

There are three volcanic belts, besides many volcanoes which are outside these belts. The three volcanic belts are as under:

1. The Circum-Pacific belt
2. The Mid-Continental belt
3. The Mid-Atlantic belt.

The Circum-Pacific belt:

This is the most important belt of volcanoes. This is the so called Ring of Fire. The Ring of Fire is an area where a large number of earthquakes and volcanic eruptions occur in the basin of the Pacific The Ring of Fire has 452 volcanoes and is home to over 75% of the world's active and dormant volcanoes It is sometimes called the **circum-Pacific belt** or the **circum-Pacific seismic belt**.About 90% of the world's earthquakes and 81% of the world's largest earthquakes occur along the Ring of Fire. The belt extends through the Andes of South America, Central America, Mexico, the Cascade Mountains of Western United States, the Aleutain Islands, Kamchatka, the Kuril Isles, Japan, the Philippines, Celebes, New Guinea, the Solomon Islands, New Caledonia and New Zealand.

The Mid-Continental belt:

This belt has various volcanoes of the Alpine mountain chain, Mediterranean Sea (Stromboli, Vesuvius, Etna etc.). Volcanoes of the Aegean Sea. Mt. Ararat, Elburz and Hindu Kush are also included in this belt. In the region where the boundaries of Iran, Afghanistan, and Pakistan meet, there are several volcanic cones of large size, and one or two of them emit steam and other gases. This region has also a few extinct volcanoes.

DID YOU KNOW?

El Salvador has about 20 volcanoes, and the area falls within the larger Pacific Ring of Fire (an area know for its frequent tectonic movements and earth activity). This Ring of Fire is the home of 75% of the world's volcanoes.

The Mid- Atlantic belt:

As the name indicates, this belt includes the volcanoes of the Mid-Atlantic Ridge. The volcanoes associated with the Atlantic Ocean are located either on swells or ridges rising from the sea floor, or on or near the edge of the continent where it slopes abruptly into the deep oceanic basins. However, in each case, the volcanoes are associated with zones of crystal movement.

The effects of volcanic eruptions

Unlike other natural disasters such as floods, wild fires and earthquakes, volcanoes can have some positive effects, even though they can be very disastrous.

Let us see some negative effects of volcanoes:

- Eruptions occurring close to human settlements may spill and destroy lives and property. People often have to be evacuated. **Example:** Chaparrastique volcano in El Salvador started erupting on 29 Dec, 2013. Anyone living within 2 miles of the volcano is evacuated.
- Ash discharged very high into the stratosphere can have negative consequences on the ozone layer.
- Landscapes and natural sceneries can be destroyed.
- Ash and mud can mix with rain and melting snow, forming lahars. Lahars are mudflows flowing at very fast pace.

Some positive effects of volcanoes include:

- Different types of erupting volcanoes provide extraordinary scenery, so beautiful and natural that they attract tourists to the area, bringing in some economic value.
- Places close to volcanic activities tend to have higher potential for geothermal energy, which can be an advantage to the towns and cities.

- Some ash and lava breakdown become soils that are rich in nutrients, and become good areas for crop planting activities.

Tsunami

Q: **Describe different causes of Tsunami'. Is there any difference between a Tsunami and a tidal wave? Name the worst Tsunami ever recorded.** (CSS-2018)

Q: **What is tsunami? How the tsunamis generated and what are their characteristics?** (CSS-2016)

What does "tsunami" mean? (CSS-2016/2018)

Tsunami is a Japanese word with the English translation, *"harbor wave."* Represented by two characters, the top character, *"tsu,"* means *harbor*, while the bottom character, *"nami,"* means *"wave."* In the past, tsunamis were sometimes referred to as *"tidal waves"* by the general public, and as *"seismic sea waves"* by the scientific community.

Characteristics (CSS-2018)

A tsunami can have wavelengths of 100 to 200 km, and may travel hundreds of kilometers across the deep ocean, reaching speed s of about 725 to 800 km/h. Upon entering shallow coastal waters, however, the waves may suddenly grow rapidly in height. When the waves reach the shore, they may be up to 30m high or more.

Tsunamis have tremendous force because of the great volume of water affected and the speed at which they travel. Just $1m^3$ of water weighs >1 ton. Although the tsunami slows to a speed of about 48 km/h as it approaches a coastline, it has a destructive force equal to millions of tons. Tsunamis are capable of obliterating coastal settlements

Causes of Tsunami (CSS-2016/2018)

A tsunami is a series of large waves generated by an abrupt movement on the ocean floor that can result from an earthquake, an underwater landslide, a volcanic eruption or - very rarely - a large meteorite strike.

However, powerful undersea earthquakes are responsible for most tsunamis. Seismologists say only earthquakes measuring greater than 7.0 on the Richter scale can produce a major tsunami.

Most earthquakes that generate tsunamis - including Friday's jolt off Japan's eastern coast - occur in areas called subduction zones, where pieces of the Earth's crust press against each other. Subduction means that one tectonic plate slides beneath another and sinks deep into the Earth's mantle.

The friction between two slow-moving plates of the Earth's crust creates vast amounts of seismic energy which is released in the form of an earthquake. When a strong undersea earthquake strikes a relatively short distance below the sea floor, it abruptly pushes up one of the immense plates of the Earth's crust. That suddenly displaces an enormous amount of ocean water which becomes a tsunami, spreading outward in every direction from the epicenter of an earthquake - like ripples on a pond, only on a much larger scale.

Tsunamis generated in the open ocean appear to be only small waves, but they can grow rapidly in size as they reach shallow water before crashing into seacoast settlements. Waves up to nine meters high have been recorded on numerous occasions, and tsunamis up to 30 meters high are believed to have occurred in the past.

Damage is usually worst in areas closest to the undersea quake, often because the fast-moving waves will hit land so quickly. Tsunamis radiate out from the site of an undersea quake nearly as fast as a jet airliner can travel, but because the expanse of the Pacific is so wide, alert systems are in place to sound a warning to those in the path of an advancing wave.

Tsunami Warnings and Preparation

Tsunamis are rare and difficult to predict. Although scientists can rapidly detect an undersea earthquake through the use of seismometers, not all undersea earthquakes will generate a tsunami. Other factors, such as the topography of the ocean floor at the epicenter of a quake, are involved.

Major Disasters

The worst tsunami disaster in history occurred in December 2004 when a magnitude 9.0 undersea earthquake, centered in the Indian Ocean off the northwestern coast of the Indonesian island of Sumatra, generated a tsunami that struck the coasts of 14 countries from Southeast Asia to northeastern Africa. Almost a month after the disaster, the United States Geological Survey (USGS) reported a death toll of more than 150,000 people as a result of the tsunami and the earthquake, with nearly two-thirds of the deaths occurring in Indonesia. High death tolls were also reported in India, Sri Lanka, and Thailand.

The World's 10 Deadliest Tsunamis (CSS-2018)

Indian Ocean (Sumatra, Indonesia)
  Estimated Number of Deaths: 300,000
  Year: 2004
Ancient Greece (Islands of Crete and Santorini)
  Estimated Number of Deaths: 100,000
  Year: 1645 B.C.
Messina, Italy
  Estimated Number of Deaths: 80,000+
  Year: 1908
Arica, Peru (now Chile)
  Estimated Number of Deaths: 70,000 (in Peru and Chile)
  Year: 1868
South China Sea (Taiwan)
  Estimated Number of Deaths: 40,000
  Year: 1782
Krakatoa, Indonesia
  Estimated Number of Deaths: 36,000
  Year: 1883
Nankaido, Japan
  Estimated Number of Deaths: 31,000
  Year: 1498
Tokaido-Nankaido, Japan
  Estimated Number of Deaths: 30,000
  Year: 1707

Hondo, Japan
  Estimated Number of Deaths: 27,000
  Year: 1826
Sanriku, Japan
  Estimated Number of Deaths: 26,000
  Year: 1896

Difference between Tidal Wave and Tsunami (CSS-2018)

A tidal wave is essentially a high tide that rises fast enough to appear in the form of a wave. It is solely affected by weather and the gravitational pull from the moon and sun. A tsunami, on the other hand, occurs when some event disturbs the ocean. They are usually caused by a geological event, such as an earthquake, volcanic eruption, or landslide.

Many consider tidal waves to be synonyms for tsunamis, however scientifically that is incorrect. In fact, tsunamis are not tidal at all. A tidal wave is essentially a high tide that rises fast enough to appear in the form of a wave. It is solely affected by weather and the gravitational pull from the moon and sun. Tides are the rise and fall of sea level that is caused by the gravitational pull of the moon and the sun on the Earth.

Tides are not only limited to the oceans, but can also occur in other systems, whenever a gravitational field is present. A majority of the Earth is affected by the gravitational force of the sun, though it is not as easily visible as it is on water. The moon has a more prominent affect on the tides, as it is much closer to the Earth compared to the sun. A wave can also be formed by wind blowing across the surface of the water. These waves are generally known as wind waves.

The term tidal wave is usually used to refer to unusual rise of water alongshore due to strong winds. They are most prominent in narrow bays or in rivers along the coast. The highest "tidal waves" are found in the Bay of Fundy, in the Canadian province of New Brunswick, where the water level can rise with the tide by 50 feet. Tidal waves may raise water level by several feet in just a matter of hours. However, it is also possible that a tidal wave will burn out before it reaches the coast. As a rule, tidal waves follow the currents and are unlikely to cause a landfall in areas of temperate climates or northern countries.

Waves – Tides & Current

Waves

The winds cause waves on the surface of the ocean (and on lakes). The wind transfers some of its energy to the water, through friction between the air molecules and the water molecules. Stronger winds (like storm surges) cause larger waves.

Tides

Tides are periodic rises and falls of large bodies of water. Tides are caused by the gravitational interaction between the Earth and the Moon. The gravitational attraction of the moon causes the oceans to bulge out in the direction of the moon. Another bulge occurs on the opposite side, since the Earth is also being pulled toward the moon (and away from the water on the far side). Since the earth is rotating while this is happening, two tides occur each day. Isaac Newton was the first person to explain tides scientifically.

The Sun's Interaction with the Tides

Spring tides are especially strong tides (they do not have anything to do with the season spring). They occur when the Earth, the Sun, and the Moon are in a line. The gravitational forces of the Moon and the Sun both contribute to the tides. Spring tides occur during the full moon and the new moon.

The *Proxigean Spring Tide* is a rare, unusually high tide. This very high tide occurs when the moon is both unusually close to the Earth (at its closest perigee, called the proxigee) and in the New Moon phase (when the Moon is between the Sun and the Earth). The proxigean spring tide occurs at most once every 1.5 years.

Neap tides are especially weak tides. They occur when the gravitational forces of the Moon and the Sun are perpendicular to one another (with respect to the Earth). Neap tides occur during quarter moons.

An Ocean Current

An ocean current is a continuous, directed movement of ocean water generated by the forces acting upon this mean flow. Such as breaking waves, wind, Coriolis effect, cabbeling, temperature and salinity differences and tides caused by the gravitational pull of the Moon and the Sun

Ocean currents can flow for great distances, and together they create the great flow of the global conveyor belt which plays a dominant part in determining the climate of many of the Earth's regions. Perhaps the most striking example is the Gulf Stream, which makes northwest Europe much more temperate than any other region at the same latitude. Another example is Lima, Peru, where the climate is cooler (sub-tropical) than the tropical latitudes in which the area is located, due to the effect of the Humboldt Current.

Avalanches

What is An Avalanche?

The word avalanche is derived from the French word avalance meaning descent. An avalanche is a mass of snow, often mixed with ice and debris which travels down mountain sides, destroying all in its path.

Types of Avalanches

To help in understanding of avalanches, they have been classified into four types.

1) **Loose Snow Avalanches**

First of these are the Loose Snow Avalanches. They are common on steep slopes and are seen after a fresh snowfall. Since the snow does not have time to settle down fully or has been made loose by sunlight, the snow pack is not very solid. Such avalanches have a single point of

origin, from where they widen as they travel down the slope.

2) **Slab Avalanches:**

Loose Snow Avalanches in turn could cause a Slab Avalanche, which are characterized by a the fall of a large block of ice down the slopes. Thin slabs cause fairly small amounts of damage, while the thick ones are responsible for many fatalities.

3) **Powder Snow Avalanches:**

Powder Snow Avalanches are a mix of the other forms, Loose Snow and Slab. The bottom half of this avalanche consists of a slab or a dense concentration of snow, ice and air. Above this is a cloud of powdered snow, which can snowball into a larger avalanche as it progresses down the slope. The speed attained by this avalanche can cross 190 miles per hour and they can cross large distances.

4) **Wet Snow Avalanches:**

Finally, there are Wet Snow Avalanches. These are quite dangerous as they travel slowly due to friction, which collects debris from the path fairly easily. The avalanche comprises of water and snow at the beginning, but understanding of avalanches has showed us that it can pick up speed with ease.

Causes of Avalanches

There is no one reason behind the development of avalanches. It was believed for long that the echo of a human voice in the mountains could dislodge enough snow to start one. Similarly, a person's weight can cause a avalanche too. The sudden addition of weight can fracture a weak area of snow. However, scientific understanding of avalanches shows us that there are many environmental factors at work.

1) **Snowstorm and Wind Direction:**

Heavy snowstorms are more likely to cause Avalanches. The 24 hours after a storm are considered to be the most critical. Wind normally blows from one side of the slope of mountain to another side. While blowing up, it will scour snow off the surface which can overhang a mountain.

2) **Heavy snowfall:**

Heavy snowfall is the first, since it deposits snow in unstable areas and puts pressure on the snow-pack. Precipitation during the summer months is the leading cause of wet snow avalanches.

3) **Human Activity:**

Humans have contributed to the start of many avalanches in recent years. Winter sport that require steep slopes often put pressure on the snow-pack which it cannot deal. Combine with the heavy deforestation and soil erosion in mountain regions, it gives the snow little stabilit in the winter months. Further natural causes include earthquakes and tremors, since they can ofte create cracks in the snow-pack.

4) **Vibration or Movement:**

The use of All Terrain Vehicles and Snowmobiles creates vibrations within the snow th it cannot withstand. Coupled with the gravitational pull, it is one of the quickest ways to cause avalanche. The other is construction work done with explosives, which tend to weaken the ent surrounding area.

5) **Layers of Snow:**

There are conditions where snow is already on the mountains and has turned into i Then fresh [illegible] which can easily slide down.

6) Steep Slopes:

Layers of snow build up and and slide down the mountain at a faster rate as steep slopes can increase the speed of snow. A rock or piece of huge ice can shake the snow and cause it to come down.

7) Warm Temperature:

Warm temperatures that can last several hours a day can weaken some of the upper layers of snow and cause it to slide down.

Effects of Avalanches

As such, there is little damage to the overall ecological system due to avalanches. They are a part of nature and have been happening for thousands of years. However, they are a major natural hazard for the local human population.

1) Damage to Life and Property:

A large number of casualties takes place after avalanches hit heavily populated areas. Infrastructure is damaged and the blockage caused, impacts the livelihood of many. People who enjoy skiing, snowboarding and snowmobiling are at a greater risk of losing their lives. A powerful avalanche can even destroy buildings and power supplies can be cut off.

2) Flash floods:

When an avalanche occurs, it brings down all the debris with it and can cause havoc in low lying areas. Flash floods are seen to happen after avalanches, which is a long term problem many villagers and townspeople have to deal with. They can also change weather patterns and cause crop failure in farms present on the lower fields.

3) Economic Impact:

An avalanche can block anything in its path and even restrict the normal movement of traffic. Various ski resorts depend on tourists to run their business successfully. Ski resorts and other businesses are forced to close until the avalanche decreases and weather conditions become suitable.

History of Recent Avalanches

Cascade range, Washington (1910)

The Cascade Range, Washington is the worst avalanche disaster in the USA to date. Three snow-bound trains were swept into a canyon which killed 118 people.

Gayari Military Base, Ghanche, Pakistan, April 2012 (138 deaths)

On April 7, 2012, an avalanche, occurring in the disputed Siachen region of Indo-Pakistan, claimed 138 victims. These included soldiers and civilian employees alike of the Northern Light Battalion at the Gayatri Military Base, Ghanche, Pakistan. This incident drew the attention of the governments of both India and Pakistan to resolve the Siachen dispute, which, since 1984, had led to the deaths of a large number of soldiers from both sides. These deaths were also primarily due to the harsh climatic conditions prevailing in the region.

1970 Huascarán-Ancash, Peru, May/June 1970 (20,000 deaths)

The worst natural disaster in the history of Peru occurred on May 31, 1970, and is known as the Ancash Earthquake, or the Great Peruvian Earthquake. The earthquake triggered an avalanche that alone claimed the lives of almost 20,000 people, making it the deadliest avalanche in the recorded history of humankind. The epicenter of the earthquake was located 21 miles off the coast of Peru in the Pacific Ocean, and the Peruvian regions of Ancash and La Libertad were the worst affected in this disaster. A massive avalanche struck the towns of Yungay and Ranrahirca when the earthquake destabilized the northern walls of Mount Huascarán. A large chunk of ice and snow, 910 meters wide and 1.6 kilometers long, sped down the mountain at speeds of 280 to 335 kilometers per hour. As it moved, it completely devastated all that came in its path, with its massive volumes of ice, water, mud, and rock alike.

Montroc, France (1999)

This avalanche occurred when 300,000 cubic metres of snow slid down a 30 degree slope which reached a speed of 60 miles an hour. Chalets were covered in 100,000 tons of snow, killing 12 people.

Alps (World War I)

During World War I approximately 50,000 soldiers died due to avalanches at the Austrian-Italian front in the Alps. It is thought the avalanches were caused by the artillery fire.

Landslides

What Are Landslides?

A landslide is a downward movement of rock and soil debris that has become detached from the underlying slope. The material can move by falling, toppling, sliding, spreading and flowing.

What Causes Landslides?

There are many possible causes of landslides these can either be geological, morphological or human-induced. A few of these include saturation of slope material (rainfall), seismic activity (earthquakes and volcanoes), undercutting of cliffs and banks by waves and rivers, removal of vegetation, and modification of slopes.

When the stability of a slope decreases or changes, even just slightly, it can make the slope unstable. This means that with a large or even a small change, can cause a landslide. However, there are many things that contribute to a landslides including;

- Erosion – if this occurs, even just slightly, can make some of the slope to fall in to oceans or rivers.
- Glaciers can also have a landslide – there is not much of a different from a cliff top. Instead, the ice melts or is subject to heavy rain and causes a slight shift from a glacier.
- Earthquakes – this brings about a sharp change in the slope and makes it unstable.
- Groundwater can destabilize the slope putting pressure on it greatly.
- Volcanoes erupting – this can cause the slope to become unstable.
- Soil structure can change.

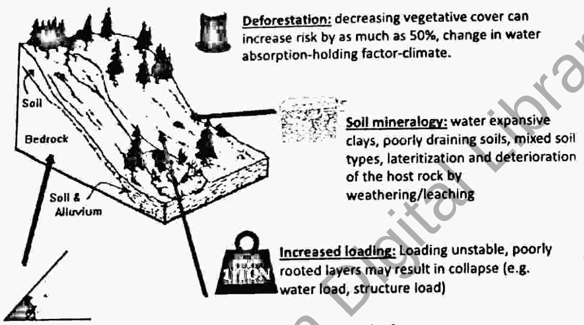
However, these are all natural causes for a landslide to occur but human activities ca contribute to cause a landslide.

- Heavy machine vibrations in the ground
- Deforestation can make fragile slopes unstable.

Shallow Landslides

Some landslides are actually shallow, which can be less dangerous. Of course, all landslides are dangerous but most of the shallow landslides are found in less populated areas meaning less damage and less devastation also. However, some landslides happen on the biggest landmarks in the world, such on mountains like Japan's Kiho. This has been the scene of deep seated landslides but still it does look magnificent to view.

Landslide: How it works



Deforestation: decreasing vegetative cover can increase risk by as much as 50%, change in water absorption-holding factor-climate.

Soil mineralogy: water expansive clays, poorly draining soils, mixed soil types, lateritization and deterioration of the host rock by weathering/leaching

Increased loading: Loading unstable, poorly rooted layers may result in collapse (e.g. water load, structure load)

Slope angle: determination of risky slopes particular for an area

Some landslides which are deep seated will mean there has been a slope failure on a large scale. The deep seated landslides are slower in movement but there are times when it could be a little faster. They will be large and create a ledge which is completely weak and could form a landslide at any given time. If the pressure is allowed to build up, there will be a landslide.

Where Can Landslides Occur?

There are many landslide vulnerable areas with high-risk terrain. These include seismic sensitive areas, mountainous areas with high relief, moderate relief areas with land degradation, areas of thick loess and areas of high rainfall.

It is not just on earth in which landslides occur. Throughout the solar system there has been evidence that landslides have occurred. This includes on Mars and Venus in which have seen landslides. In fact, scientists have had trained satellites orbiting the planets to view the landslides.

Recent Landslides

There have been many landslides throughout the years including the Rio de Janeiro landslide in 2011 which caused over 600 deaths. There are other major landslides including the Cairo landslide in 2008, the Devil's Slide in California and the Vargas mudslide which all caused a lot of damage and devastation. There has been dozens, hundreds in fact, across the world and it has been so difficult to know how to deal with a landslide.

Nevados Huascaran, Andes (1962)

On January 10th 1962, a huge mass of rock and glaciated ice fell down Nevados Huascaran initiating a debris flow. The flow travelled along the river valleys leading from the mountain. It destroyed the town of Ranrahirca, killing 2,000 people. On May 31st 1970, an earthquake measuring 7.9 on the Richter scale occurred 85 miles away from the mountain. The same area affected by the 1962 landslide gave way, burying the town of Yungay. 18,000 people were lost beneath 30 metres of rock.

Gansu Province, NW China (1920)

On December 16th 1920 an earthquake measuring 8.6 on the Richter scale started a landslide due to the fine loess material in the area. The loess (wind deposited silt) is strong enough to form near vertical slopes which are easily weakened during seismic activity. The landslide flowed down the valleys, burying villages and killing approximately 180,000 people.

Monsoon landslides, Nepal (2002)

Extreme temperatures and annual monsoon season led to rapid rock weathering and heavy rainfall. It is also thought that deforestation also played its part in the areas landslide vulnerability. Extremely heavy monsoon rainfall lead to severe flooding in south-east Asia, this lead to landslides in Nepal, killing 500 people. 92% of the population live in the hills or in the lowlands beneath the mountains.

El Salvador, Central America (2001)

A recent series of landslides occurred in El Salvador following an earthquake measuring 7.7 on the Richter scale, killing 585 people. The landslide volume is estimated to be 250,000 cubic metres.

What is a Flood?

A flood refers to "high-water stage in which water overflows its natural or artificial banks onto normally dry land, such as a river inundating its floodplain"

When flooding occurs, a piece of area gets submerged under water suddenly because the amount of water is too much for the land (within the confines of the affected area) to absorb or when natural watercourses do not have the capacity to convey the excess water.

While the occurrence of a flood is usually due to an act of nature such as heavy rainfall, it can also occur in situations when a dam is damaged (usually caused by earthquakes) causing flooding in downstream areas. Floods can occur in almost anywhere including deserts.

Floods occur at irregular intervals and vary in size, duration and the affected area.

It is important to note that water naturally flows from high areas to low lying areas. This means low-lying areas may flood quickly before it begins to get to higher ground.

How Floods Develop

A flood occurs when water overflows or inundates land that's normally dry. This can happen in a multitude of ways. Most common is when rivers or streams overflow their banks. Excessive rain, a ruptured dam or levee, rapid ice melting in the mountains, or even an unfortunately placed beaver dam can overwhelm a river and send it spreading over the adjacent land, called a floodplain. Coastal flooding occurs when a large storm or tsunami causes the sea to surge inland.

Most floods take hours or even days to develop, giving residents ample time to prepare or evacuate. Others generate quickly and with little warning. These flash floods can be extremely dangerous, instantly turning a babbling brook into a thundering wall of water and sweeping everything in its path downstream.

Disaster experts classify floods according to their likelihood of occurring in a given time period. A hundred-year flood, for example, is an extremely large, destructive event that would theoretically be expected to happen only once every century. But this is a theoretical number. In reality, this classification means there is a one-percent chance that such a flood could happen in *any* given year. Over recent decades, possibly due to global climate change, hundred-year floods have been occurring worldwide with frightening regularity.

What causes flooding?

Here are a few events that can cause flooding:

Rains

Each time there are more rains than the drainage system can take, there can be floods. Sometimes, there is heavy rain for a very short period that result in floods. In other times, there

may be light rain for many days and weeks and can also result in floods.

River overflow

Rivers can overflow their banks to cause flooding. This happens when there is more water upstream than usual, and as it flows downstream to the adjacent low-lying areas (also called a floodplain), there is a burst and water gets into the land.

Strong winds in coastal areas

Sea water can be carried by massive winds and hurricanes onto dry coastal lands and cause flooding. Sometimes this is made worse if the winds carry rains themselves. Sometimes water from the sea resulting from a tsunami can flow inland to cause damage.

Dam breaking

Dams are man-made blocks mounted to hold water flowing down from a highland. The power in the water is used to turn propellers to generate electricity. Sometimes, too much water held up in the dam can cause it to break and overflow the area. Excess water can also be intentionally released from the dam to prevent it from breaking and that can also cause floods.

Ice and snow-melts

In many cold regions, heavy snow over the winter usually stays un-melted for some time. There are also mountains that have ice on top of them. Sometimes the ice suddenly melts when the temperature rises, resulting in massive movement of water into places that are usually dry. This is usually called a *snowmelt flood*

Types of floods

Flash floods

This kind occurs within a very short time (2-6 hours, and sometimes within minutes) and is usually as a result of heavy rain, dam break or snow melt. Sometimes, intense rainfall from slow moving thunderstorms can cause it. Flash floods are the most destructive and can be fatal, as people are usually taken by surprise. There is usually no warning, no preparation and the impact can be very swift and devastating.

Rapid on-set floods

Similar to flash floods, this type takes slightly longer to develop and the flood can last for a day or two only. It is also very destructive, but does not usually surprise people like Flash floods. With rapid on-set floods, people can quickly put a few things right and escape before it gets very bad.

Slow on-set floods

This kind is usually as a result of water bodies over flooding their banks. They tend to develop slowly and can last for days and weeks. They usually spread over many kilometers and occur more in flood plains (fields prone to floods in low-lying areas). The effect of this kind of floods on people is more likely to be due to disease, malnutrition or snakebites.

Effects of flooding

In Pakistan, the Indus River system offers the world's largest contiguous irrigation system, thereby, supporting the fertile flood plains downstream Terbela. Floods particularly hit Punjab and Sindh while hill torrents/flash floods tend to affect the hilly areas of KP, GB and Balochistan. The floods of 1950, 1973, 1976, 1988 and 1992 resulted in a large number of deaths and severe loss of property, while the July 2010 floods have been described as the worst in the last eighty years and led to nearly 20 million people being significantly affected with an estimated 1,800 human loss. The estimated loss to economy was about USD 10 Billion.

(NDMA Annual Report 2011)

Pakistan before the Floods (2010)

- Pakistan is 125th of 169 countries in the Human Development Index
- 22% of people live in extreme poverty: they survive on less than $1.25 (US) per day
- 23% of people are undernourished
- 25th highest infant mortality rate in the world

The Impact of the Floods (2010)

- Unprecedented monsoon rains caused flooding of the Indus river, starting in Khyber Pakhtunkhwa, spreading South through Punjab, Balochistan and Sindh.
- At its worst the flood waters covered roughly one-fifth of Pakistan's land area
- 18 million people were affected
- 1,985 people killed
- 12 million people's homes were damaged or destroyed
- 2.2 million hectares of crops were destroyed
- 10.000 schools damaged or destroyed
- 450,000 livestock lost

Floods can have devastating consequences and can have effects on the economy, environment and people.

Economic

During floods (especially flash floods), roads, bridges, farms, houses and automobiles are destroyed. People become homeless. Additionally, the government deploys firemen, police and other emergency apparatuses to help the affected. All these come at a heavy cost to people and the government. It usually takes years for affected communities to be re-built and business to come back to normalcy.

Environment

The environment also suffers when floods happen. Chemicals and other hazardous substances end up in the water and eventually contaminate the water bodies that floods end up in. In 2011, a huge tsunami hit Japan, and sea water flooded a part of the coastline. The flooding caused massive leakage in nuclear plants and has since caused high radiation in that area. Authorities in Japan fear that Fukushima radiation levels are 18 times higher than even thought.

Additionally, flooding causes kills animals, and others insects are introduced to affected areas, distorting the natural balance of the ecosystem.

People and animals

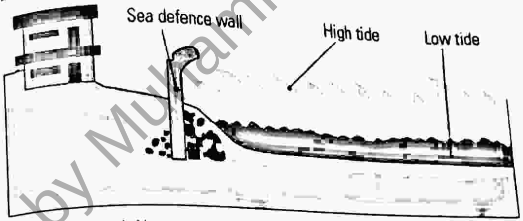
Many people and animals have died in flash floods. Many more are injured and others made homeless. Water supply and electricity are disrupted and people struggle and suffer as a result. In addition to this, flooding brings a lot of diseases and infections including military fever, pneumonic plague, dermatopathia and dysentery. Sometimes insects and snakes make their ways to the area and cause a lot of havoc.

But there is also something good about floods, especially those that occur in floodplains and farm fields. Floodwaters carry lots of nutrients that are deposited in the plains. Farmers love such soils, as they are perfect for cultivating some kinds of crops.

Methods of flood prevention

Humans cannot stop the rains from falling or stop flowing surface water from bursting its banks. These are natural events, but we can do something to prevent them from having great impact. Here are a few.

Sea / Coastal Defence Walls



Sea walls and tide gates have been built in some places to prevent tidal waves from pushing the waters up ashore. In some areas too, sand bags are made and placed in strategic areas to retain floodwaters.

Retaining walls

In some places, retaining walls levees, lakes, dams, reservoirs or retention ponds have been constructed to hold extra water during times of flooding.

Town planning

It is important that builders acquire permission before buildings are erected. This will ensure that waterways are not blocked. Also, drainage systems must be covered and kept free from objects that chock them. This way, water can quickly run through if it rains and minimize any chance of town flooding. Drainage systems should also be covered to prevent litter from getting into them.

Vegetation

Trees, shrubs and grass help protect the land from erosion by moving water. People in low-lying areas must be encouraged to use a lot of vegetation to help break the power of moving flood water and also help reduce erosion.

Education

In many developing countries, drainage systems are chocked with litter and people have little knowledge of the effects that can have during a rain. When it rains, waterways and culverts are blocked by massive chunks of litter and debris, and water finds its way into the streets and into people's homes. Education is therefore very important, to inform and caution people about the dangers of floods, what causes floods, and what can be done to minimise its impact.

Detention basin

These are small reservoirs built and connected to waterways. They provide a temporary storage for floodwaters. This means in an event of flooding, water is drained into the basin first, giving people more time to evacuate. It can also reduce the magnitude of downstream flooding.

What is a drought?

Drought, also spelled *drouth*, lack or insufficiency of rain for an extended period that causes a considerable hydrologic (water) imbalance and, consequently, water shortages, crop damage, streamflow reduction, and depletion of groundwater and soil moisture. It occurs when evaporation and transpiration (the movement of water in the soil through plants into the air) exceed precipitation for a considerable period. Drought is the most serious physical hazard to agriculture in nearly every part of the world. Efforts have been made to control it by seeding clouds to induce rainfall, but these experiments have had only limited success.

The distribution of all the water on the earth's surface is not even. Some places have lots of fresh water (rivers, lakes, lagoons, ponds etc.) and are continuously replenished by rainfall, runoffs and water from underground. Others places too are known to have very little water.

Therefore, if a region that has lots of rainfall, goes for a couple of weeks without rains, and people, animals and plants begin to experience a bit of dryness, it can be called a drought. At the same time, that condition may be very normal for places with no water, and can go for months without any rains with little problems.

Kinds of Drought

There are four basic kinds of drought:

1) **Permanent drought** characterizes the driest climates; the sparse vegetation is adapted to aridity, and agriculture is impossible without continuous irrigation.
2) **Seasonal drought** occurs in climates that have well-defined annual rainy and dry seasons; for successful agriculture, planting must be adjusted so that the crops develop during the rainy season.
3) **Unpredictable drought** involves an abnormal rainfall failure; it may occur almost anywhere but is most characteristic of humid and subhumid climates. Usually brief and irregular, it often affects only a relatively small area.

4) **Invisible drought** can also be recognized; in summer, when high temperatures induce high rates of evaporation and transpiration, even frequent showers may not supply enough water to restore the amount lost; the result is a borderline water deficiency that diminishes crop yields.

Causes of drought

Lack of rainfall (or precipitation)

Droughts can occur when there is the lack of 'expected' precipitation (rain and snow). Note that we say 'expected' because the lack of rain alone does not mean a drought. Some regions can go for months without any rain, and that would be 'normal' for them. Farmers plant in anticipation of rains and so when the rains do not come, and irrigation infrastructure is absent, agricultural drought occur.

Surface water flow

Some regions are also well distributed with surface water (streams and rivers) that have their sources from far away mountains and watersheds. These surface waters may dry out if the flow from their sources upstream is affected. Hydro-electric dams and irrigation systems are some of the economic activities that can reduce the amount of water flowing to other areas downstream.

Human factors

Forests (trees) play a key role in the *water cycle*, as they help reduce evaporation, store water and also contribute to atmospheric moisture in the form of transpiration. This means, cutting down trees (*deforestation*) in the name of economics, will expose surface water to more evaporation. It will also reduce the ability of the ground to hold water and make it easier for desertification to occur. It can set off drying conditions, especially for smaller water bodies. Cutting down trees is known to reduce a forest's watershed potential.

Global Warming

Even though some people do not accept that the average temperature of the earth has risen, it is on record that human actions have contributed to more *greenhouse gasses* in the atmosphere. As a result, there are warmer temperatures, often resulting in more dryness and bush fires. These conditions also tend to speed up drought conditions.

Harmful Effects of Droughts

Economic Effects

Economic effects of droughts usually involve loss of money by governments, enterprises, families or individuals. Below is an outline of the main economic impacts of droughts:

- Farmers will have to contend with spending huge sums of money for irrigation and watering animals. This involves drilling wells or buying water from far distances.
- Low yields equal loss of substantial income. Low yields also lead to pay cuts and layoffs to farm workers.
- Businesses and industries that produce farm equipment may close down since farmers have no money to purchase equipment.
- Prolonged shortage of rains means drier conditions. This makes an area susceptible to wildfires. Wildfires can destroy property; devastate farms and burn down forests. Governments spend millions to control or put out wildfires annually. All this affects the economy of the region.
- If water supply plummets, hydropower plants operate below capacity, and this means businesses have to pay more for electricity or incur the cost of using their own generators.

Energy firms also lose out since they are unable to satisfy energy demands of the region. The government also loses a big chunk of tax revenue.

Environmental Effects

- Droughts lead to decimation of habitats. Water bodies such as rivers, lakes, ponds, lagoons, and creeks dry out, and this leads to death of water animals.
- Soil moisture is critical to the breakdown of organic matter. Droughts compromise soil quality since there is less to zero organic activity because organisms have died.
- Droughts magnify the impacts of desertification by wiping out any chance of land recovering.
- The quality and health of surface water bodies such as rivers, streams, lakes, and ponds are enormously impacted. This endangers living organisms depending on the water for survival.
- Wildlife walk long distances in search of water. They end up in new dangerous habitats that can lead to their demise.

Social Effects

The social effects of drought are the most potent since they directly impact humans. Many in the third world countries that have experienced drought can attest to their severity.

Black Blizzards

Have you heard of the *Dust Bowl*? Between 1933-1940, severe droughts in the great plains of the USA resulted in massive dust storms that left thick dust in the clouds for days. This dust cloud was nicknamed ***'black blizzards'***. The extremely dry conditions exposed the top layers of the land to wind action. The real cause of the dust bowl is known to be the severe drought and the failure to apply crop farming methods that were resistant to wind erosion.

- Water maintains our health. Sanitation and clean drinking water are critical to a healthy body. Droughts lead to malnutrition, anemia, and hunger.
- Droughts trigger migrations. This means the area will lack young and working population, a critical ingredient to the development of any region.
- Lack of control over when the drought ends can have far-reaching psychological effects like stress, anxiety, and depression. Social interaction reduces and community networks get broken.

Planning to minimize the impact of droughts

Unlike a hurricane or tropical storm, no one can keep a watch on when a drought is coming and when it will end. However, there are many things an individual, community or government can do to minimize the impact of drought if they occur. The term for taking precautions to minimize drought risk is 'Drought Mitigation'

Here are a few:

Education

It is important that each of us learn about how droughts occur and how they affect us. This empowers us to think of solutions and other things we can do if we find ourselves in a drought. The government (or authorities) also need to educate the public periodically about their environment, climate, weather and some natural disasters that can happen. The government also needs to understand the terrain of the region and the likelihood of a drought, so that there are no surprises if they happen.

Stop Pollution

Taking measures to stop all forms of water pollution is important, because on the onset of droughts, humans resort to surface water such as streams and lakes and the like. If those are in great condition, humans can depend on them for drinking and irrigation until things improve. If they are all polluted or contaminated and unsafe for any kind of use, it makes the problem even more distressing.

Water conservation and storage

Water is precious and a scarce commodity everywhere in the world and humans need to use water wisely as such. Even if there is water available, it is important because the practice makes us cope better when there is a shortage. Also, preserving water leaves enough to be stored in dams, reservoirs and even turned into ponds.

Pakistan could face mass droughts by 2025

Pakistan could be facing a severe drought soon according to country experts, who have warned that the country will approach "absolute scarcity" levels of water by 2025.

The Pakistan Council of Research in Water Resources (PCRWR) made the alarming forecast in a report, which claimed the country touched the "water stress line" in 1990 before crossing the "water scarcity line" in 2005

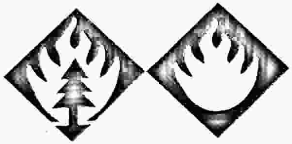
Pakistan has the world's fourth highest rate of water use but is largely dependent on water from the Indus River basin. Rainfall in the country has been steadily declining, with some experts claiming this is down to climate change.

An estimated million people live in Karachi but very few have running water after the land has gradually dried up, forcing locals in some areas to queue for hours for supplies to be given to them.

With only 494mm of precipitation per year, Pakistan is already one of the wettest countries in the world, according to the World Bank.

People must learn to conserve water, even if there is no drought. With the right attitude towards water, we are better prepared to face the impact in case there is a shortage.

Sometimes (especially in developed nations) canals and pipelines are built to connect places with abundant water to places with less water. Projects like that can be very expensive, but they ensure that during droughts, there can be some water flow until traditional water supply sources improve.



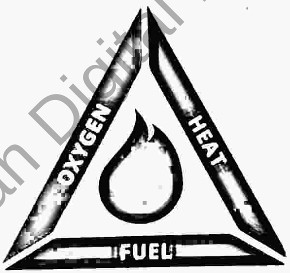
Wildfire and Urban Fires

Wildfire and urban fires describes an uncontrolled burning fire, usually in wild lands, which can cause damage to forestry, agriculture, infrastructure and buildings.
Out of the many natural disasters we have, wild fires would be one that is very common, very difficult to fight, and maybe the most dangerous.
What is a fire?
Simple, it is the visible part of a combustion. A combustion is a chemical reaction of three things: ***Heat, fuel and Oxygen***. These three ingredients must be present before a fire can be made and maintained.

For the fire triangle to stand, all three ingredients must be present. If the heat is not enough, or the fuel runs out, or the oxygen runs out, the fire will be out.

Oxygen:

This is simply a gas found in air. The air we breath contains about 21% of oxygen. In fact, only 16% is all that is needed to produce fire. When fuel burns, it reacts with oxygen from the surrounding air. This chemical reaction releases heat and other products such as gases, smoke and particles. This process is known as ***oxidation***. This is why some smoke can be very dangerous because depending on what is burning, the gases produced can be very deadly.



Fuel:

Fuel is any kind of combustible material. This can be gas, liquids or solids. Examples of solid fuels include wood, dry leaves and even paper. Examples of liquid fuels include petro and turpentine. Examples of gas fuels include LPG Gas. Fuels with less moisture tend to burn faster than fuels with high moisture.

Heat:

Heat is thermal energy. You may not see it, but can feel it. Extreme heat of about 617°F will start a fire in the presence of fuel and oxygen. Heat eliminates moisture from any nearby fuel, warms the air around and prepares the fire path to accept the fire and make it burn with ease.

What is a wildfire?

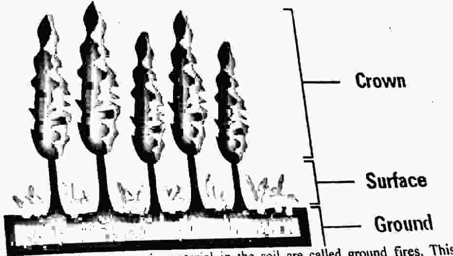
A wildfire is simply an uncontrolled fire that is wiping out large fields and areas of land. It is typically fires that started out of a lightning strike, or people carelessly starting it, or accidentally, or even arson, that went un-noticed and got out of hand. These fires sometimes burn for days and weeks. They can wipe out an entire forest and destroy almost every organic matter in it.

Wild fires can also be termed *forest fires, grass fires, peat fires and bush fires* depending on type of vegetation being burnt. Note that these fires tend to thrive in very warm and dry climates, rather than the thick, moist rainforest types.

Wildfires and forests

The destructive nature of a wildfire in a forest is phenomenal. A forest is an entire ecosystem consisting of biotic factors like animals, insects, birds, bacteria, plants and trees. It also consists of abiotic factors like water, rocks and climate in that forest area. If a wildfire strikes such an ecosystem, all life forms will be lost. The air and water will be heavily polluted. The soils will be badly degraded and other abiotic elements will be affected including water catchment areas.

Different wildfires burn differently.



Fires that burn organic material in the soil are called ground fires. This is a slower burning fire, usually under litter or under vegetation. They burn by glowing combustion.

Some fires burn on the surface of the ground. They burn dry leaves, broken twigs and branches and other materials on the ground. These fires spread quickly and are known as surface fires.

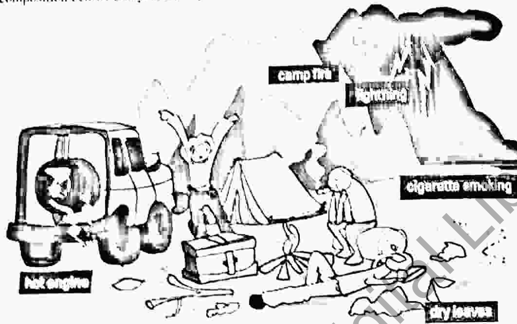
Crown fires burn with huge flames and has intense heat and power. They burn from tree top to tree top and spread very quickly with the wind and heat. It is even worse if they are exposed to steep slopes.

Spotting, is yet another interesting fire type. Sometimes winds blow 'firebrands' away from crown fires onto new areas. Firebrands are like fireball that fly from burning treetops to other new places, resulting in new fires and keeps the fires xsspreading.

Conflagration: This is a large fire with a character of aggravation, usually enhanced with wind action and firebrands.

How does a wildfire start?

Below are the most common ways in which wildfires are started. Take a look at the composition below. Can you identify some fire hazards?



Campfires:

In many places, camping is a big thing. People, both young and old spend time in the woods to enjoy the great outdoors. Sometimes fires are needed for various things during camping and they can start wildfires if not put out properly.

Smoking:

Some people smoke whiles driving, biking or walking. Sometimes the buds are not properly extinguished and thrown away. You never know where that bud will end up and start a fire.

Lightning:

A good number of wildfires were started by lightning. It is a bit hard to imagine, but investigators confirm this as very common. When lightning strikes, it can produce a spark. It can strike trees, power cables, rocks and many other things and just set them off.

Burning debris:

Refuse, junk and yard waste are common items that are permitted to burn in many places. People are therefore very quick to set anything ablaze as a way of disposing off them. But that can get out of hand and start a fire.

Accidents or equipment failure:

Car crashes, gas balloons, lawn mowers and many other equipment have been known to start fires when they go wrong. These are accidental but if not detected quickly, can cause massive problems. This is why fire fighters always move to an accident scene in anticipation of a fire break.

Fireworks:

Fireworks are banned in many places because of their explosive nature and high potential to start a fire. If fireworks are not blasted at the right places, they can end up as fires elsewhere.

Arson:

This is the act of setting fire to a property, piece of land or anything with the intention of causing damage. A person who does this is called and arsonist. Arson specialists believe that many fires are started by arsonists, and may account for about 30% of all wildfire cases

What are the effects of wildfires?

Economic cost:

If you have ever seen firefighters battling a wildfire and the images they show on TV, it will give you an idea of the immediate damage it can do to wildlife and vegetation. Fires also destroy houses and almost anything in its way. Additionally, the city spends millions of money to fight them with chemicals, logistics, aircrafts and trucks, time and personnel. The economic loss can be huge.

Soils and organic matter:

Take forest soils for example. Forest soils are rich in decaying debris and nutrients, and are composed of many natural features that support a myriad of life forms and organic activities. Wildfires raise the temperatures of these soils to over 900°C and this potentially wipes away almost all the organic value of the soil.

Watershed:

The effect on watershed is also key. Burned organic matter in the soil (volatized organic compounds) also affect the natural layering of the soils. This negatively affects infiltration and percolation, making the soil surfaces water repellent. Water therefore is unable to drain into water tables and the run-offs on the surfaces cause erosion.

Researchers believe that forest fires are not all that bad, as they have some benefits too. In fact, they believe that even though young animals and birds may die, many animals are able to escape or move away from fires. Birds fly away, dear and other reptiles find their own escape routes and so on.

Many plants easily grow back and there is usually good recovery after a fire. Some plants have their seeds opened up and exposed to ash-enriched soils. Examples include serotinus cones, from a tree species such as jack pine. Species like white pine and yellow birch also benefit from forest fires in a similar way.

Fighting wildfires

Different fires are fought differently, but the big idea is usually the same — to deprive the fire of its fuel and let it go out by itself. This can be achieved in many ways.

Fire lines or Firebreaks

With bull dozers and land equipment, firefighters clear a ring around the fire area and to get rid of all fuel in the fire's path. As the fire gets to the ring, it can no longer spread as there is no fuel in its path.

Firing out

Fire fighters look for a natural edge or boundary, such as a road, stream or plain field, and they do a controlled burn of all the fuel between the barrier and the fire. This means that before the fire gets there, it would have already burned out.

Aircrafts

Special aircrafts call air tankers fly over the fire and dump water, fire retardant (*eg.* the pink coloured one is called jelly-o) and chemicals (*foam*) on the fire. An example of such chemical is ammonium phosphate. Sometimes suspended buckets of between 100 to 2000 gallons carry water and sprinkle it over the fires. In some developed countries, special pilot-less air tankers controlled by computers do this job so that no human is put in harms way.

Technology

These days, satellites, computers, aircrafts and digital equipment are used to monitor fires, forecast wind directions and create instant and effective maps and information needed to fight fires. This makes it a lot easier and quicker for firefighters to contain and put out fires.

Firemen

Trained firefighters are key to fighting fires. They get into gear (wear oxygen masks, appropriate fire-proof clothing) and carry important tools on them to fight fires. One good fireproof material used in their clothing is called Nomex. Sometimes they also carry fire shelters if they get close to fires. There are special tents protect them from extreme heat incase they are trapped by the fires.

Urban Fire

Urban fire occurs primarily in cities or towns with the potential to rapidly spread to adjoining structures. These fires damage and destroy homes, schools, commercial buildings and vehicles.

Common Causes of House Fires (Urban Fire)

Cooking Equipment

When a pot or pan overheats or *splatters greases*, it can take seconds to cause a fire. Stay in the kitchen when cooking, especially if using oil or high temperatures; most kitchen fires occur because people get distracted and leave their cooking unattended. Keep combustibles (e.g. oven mitts, dish towels, paper towels) away from heat sources.

Heating Equipment

Have your furnace *inspected annually by a qualified technician*, and your chimney cleaned and inspected annually. Keep portable heaters at least one metre away from anything that can burn (*including curtains, furniture, and you*), and don't use your heaters to dry shoes or clothes. Install a carbon monoxide alarm to alert you to deadly carbon monoxide gas.

Careless Smoking

Make the bedroom off-limits to smoking, and supervise smokers who may become drowsy (*i.e.* on medication, drinking) or forget to extinguish their cigarette. Use large, deep ashtrays; never place an ashtray on or near anything that will burn; and check furniture for fallen cigarettes/embers (a butt can smoulder for hours before causing furniture to burst into flames).

Electrical Equipment

Ensure the following:

- Your electrical appliances don't have loose or frayed cords/plugs

- Your outlets aren't overloaded with plugs
- You're not running electrical wires under rugs or heavy furniture
- You're not overusing an extension cord. Be careful about do-it-yourself electrical projects; many home fires are caused by *improper installation*, so use a licensed electrician.

Candles

Keep candles in a sturdy holder on a level surface, away from combustible materials and out of the reach of children or pets. Blow them out before leaving the room.

Children Playing with Fire

Children cause fires out of curiosity (what happens when something burns) or mischief (*they're angry, upset or destructive, and fire is a major taboo to break*). Kids may be involved in fire play if you find matches or lighters in their room/possession, smell sulphur in their room, and/or find toys or other personal effects that appear melted/singed.

Inadequate Wiring

Older homes and apartments can have inadequate wiring—a fire and an electrical hazard.

Flammable Liquids

Flammable liquids—fuels, solvents, cleaning agents, thinners, adhesives, paints, and other raw materials—can ignite or explode if stored improperly. The vapours can easily ignite from even just high temperatures or weak ignition sources (*one spark of static electricity*). Don't store flammable liquids near a heating source but, ideally, outside the home in a cool ventilated area, in approved containers.

Barbecues

As part of regular maintenance, clean removable parts (inside and out) with soapy water. Spray the connections with soapy water to check for potential leaks; watch if bubbles form when you open the gas. Use barbecues away from your home, deck rails, tablecloths and tree limbs. Use barbecues outdoors, never indoors (including garages).

Tropical Cyclone

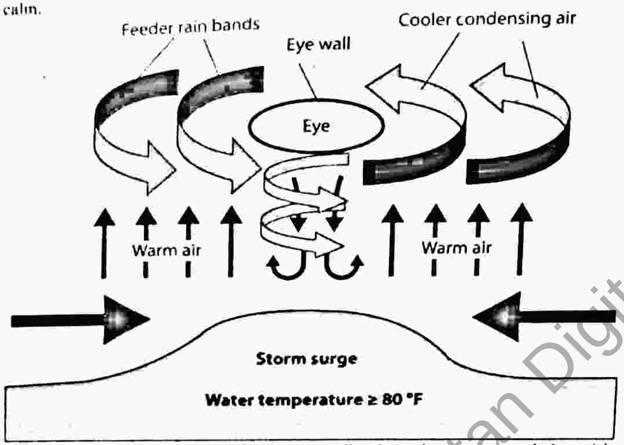
Tropical cyclone, also called *typhoon* or *hurricane*, an intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain. Drawing energy from the sea surface and maintaining its strength as long as it remains over warm water, a tropical cyclone generates winds that exceed 119 km (74 miles) per hour. In extreme cases winds may exceed 240 km (150 miles) per hour, and gusts may surpass 320 km (200 miles) per hour.

Tropical cyclones are known by various names in different parts of the world. In the North Atlantic Ocean and the eastern North Pacific they are called hurricanes, and in the western North Pacific around the Philippines, Japan, and China the storms are referred to as typhoons. In the western South Pacific and Indian Ocean they are variously referred to as severe tropical cyclones, tropical cyclones, or simply cyclones. All these different names refer to the same type of storm.

Anatomy of a cyclone

Tropical cyclones are compact, circular storms, generally some 320 km (200 miles) in diameter, whose winds swirl around a central region of low atmospheric pressure. The winds are driven by this low-pressure core and by the rotation of Earth, which deflects the path of the wind through a phenomenon known as the Coriolis force. As a result, tropical cyclones rotate in a counterclockwise (or cyclonic) direction in the Northern Hemisphere and in a clockwise (or anticyclonic) direction in the Southern Hemisphere.

The wind field of a tropical cyclone may be divided into three regions. First is a ring-shaped outer region, typically having an outer radius of about 160 km (100 miles) and an inner radius of about 30 to 50 km (20 to 30 miles). In this region the winds increase uniformly in speed toward the centre. Wind speeds attain their maximum value at the second region, the eyewall, which is typically 15 to 30 km (10 to 20 miles) from the centre of the storm. The eyewall in turn surrounds the interior region, called the eye, where wind speeds decrease rapidly and the air is often calm.



Bordering the eye of a storm is the eye wall, where the strongest winds and heaviest rainfall are found. This is the most violent part of the hurricane. Beyond the eye wall are feeder bands, with thunderstorms and rain showers that spiral inward toward the eye wall. Feeder bands can extend out for many miles and increase as the heat engine feeds the storm. Hurricanes lose their energy when they move over land because of the lack of heat generation. Once on land, the storm system breaks down. Rainfall and winds can continue, but with decreased intensity

How do hurricanes form?

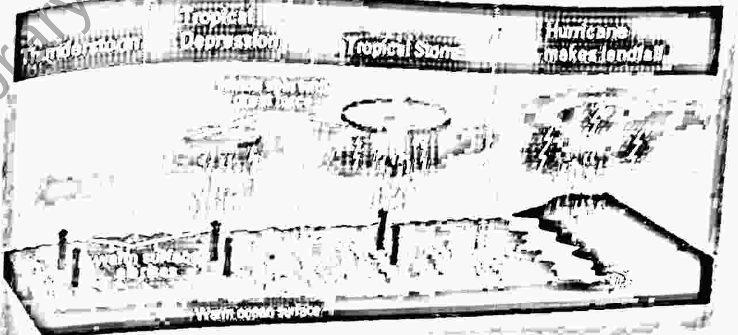
Hurricanes only form over warm ocean waters of about 80°F. This is why it is common in the tropics where temperatures are high all year round. Hurricanes also need wind action to form. Now here is the fun part:

Warm air, together with moisture from evaporation from the ocean surface rises, creating low pressure on the water surface, which is immediately replaced by cooler air. This process continues, and the resulting moisture-laden clouds begin to expand. Thunderstorms with rains form.

The thunderstorms with rains begin to move slowly with mild western winds (a lot of wind action will disperse the buildup). In a day or two, stronger vertical currents build up over the ocean surface upward. More warm air rises and the winds begin to move in a circular manner, caused by the earth's rotation. The rising warm air causes pressure to decrease at higher altitudes. The entire system is now in a circular motion around a central point. This is called a **tropical depression** and they have wind speeds going up to about 38 miles per hour.

In a couple of days, as the system moves over more warmer waters, the clouds expand even more, and the winds begin to speed up. Gale force winds, thunderstorms and heavy rains are in full force at this point. This may be called a **tropical storm,** and they have wind speeds up to 74miles per hour.

Continuing its movement westward, the tropical storm may be moving over even warmer waters. The energy from the warm ocean, in the form of very warm air rising and the gushing of cooler air replacing it throws the entire storm into a fury of powerful, huge and monstrous spiral storm that can be seen from space. The spiral has a calm center called the **eye.**



The eye, is surrounded by a towering and extremely dangerous vertical movement of thunderstorms. This is called the eye wall. The winds of the eye wall is so powerful that it spins and carries huge amounts of ocean water as it moves ashore.

The hurricane has now made a landfall (*has reached land*). With winds over 74mph to about 160mph, massive destruction is usually inevitable. As the system is no more over water, its' fuel has run out and begins to ease out. The winds will subside and eventually end, but the rains may continue.

Life of a cyclone

A circulation system goes through a sequence of stages as it intensifies into a mature tropical cyclone. The storm begins as a tropical disturbance, which typically occurs when loosely organized cumulonimbus clouds in an easterly wave begin to show signs of a weak circulation. Once the wind speed increases to 36 km (23 miles) per hour, the storm is classified as a tropical depression. If the circulation continues to intensify and the wind speeds exceed 63 km (39 miles) per hour, then the system is called a tropical storm. Once the maximum wind speed exceeds 110 km (74 miles) per hour, the storm is classified as a tropical cyclone.

There are six conditions favourable for this process to take place. The conditions are listed first below, and then their dynamics are described in greater detail:

1) The temperature of the surface layer of ocean water must be 26.5 °C (80 °F) or warmer, and this warm layer must be at least 50 metres (150 feet) deep.
2) A preexisting atmospheric circulation must be located near the surface warm layer.
3) The atmosphere must cool quickly enough with height to support the formation of deep convective clouds.
4) The middle atmosphere must be relatively humid at a height of about 5,000 metres (16,000 feet) above the surface.
5) The developing system must be at least 500 km (300 miles) away from the Equator.
6) The wind speed must change slowly with height through the troposphere—no more than 10 metres (33 feet) per second between the surface and an altitude of about 10,000 metres (33,000 feet).

Hurricane names - how are they decided?

Hurricane Irma, the most powerful Atlantic Ocean hurricane in recorded history, has already made landfall in the island of Barbuda and is set to affect more Caribbean islands in the days to come.

Why do hurricanes need names?

Names have been given to storms (or tropical cyclones) for at least the last 100 years. According to the World Meteorological Organization (WMO), it is easier for people to remember names than numbers and technical terms.

When reported by the media, this in turn makes it easier to generate interest in major storms and therefore increase how prepared people are for a major storm to hit

How are hurricane names chosen?

In the beginning, storms were given arbitrary names. An Atlantic storm that ripped the mast off a boat named Antje became known as Antje's hurricane. Then, in the mid-1900s, people started using female names for storms.

Then, meteorologists decided to introduce a more organised and efficient system, taking names instead from a list arranged alphabetically.

The first storm to occur in a year would be assigned a name beginning with A, and so on. Before the end of the 1900s, forecasters used male names for storms forming in the southern hemisphere.

Since 1953, storms in the Caribbean Sea, Gulf of Mexico and the North Atlantic have been named from lists drawn up by the National Hurricane Center. They are now maintained and updated by an international committee of the WMO.

The original list featured only women's names and in 1979, men's names were introduced - and now they alternate each year. Six lists are used in rotation, so the list for 2016 will be used again in 2022.

Caribbean Sea, Gulf of Mexico and the North Atlantic

2016	2017	2018	2019	2020	2021
Alex	Arlene	Alberto	Andrea	Arthur	Ana
Bonnie	Bret	Beryl	Barry	Bertha	Bill
Colin	Cindy	Chris	Chantal	Cristobal	Claudette
Danielle	Don	Debby	Dorian	Dolly	Danny
Earl	Emily	Ernesto	Erin	Edouard	Elsa
Fiona	Franklin	Florence	Fernand	Fay	Fred
Gaston	Gert	Gordon	Gabrielle	Gonzalo	Grace
Hermine	Harvey	Helene	Humberto	Hanna	Henri
Ian	Irma	Isaac	Imelda	Isaias	Ida
Julia	Jose	Joyce	Jerry	Josephine	Julian
Karl	Katia	Kirk	Karen	Kyle	Kate
Lisa	Lee	Leslie	Lorenzo	Laura	Larry
Matthew	Maria	Michael	Melissa	Marco	Mindy
Nicole	Nate	Nadine	Nestor	Nana	Nicholas
Otto	Ophelia	Oscar	Olga	Omar	Odette
Paula	Philippe	Patty	Pablo	Paulette	Peter
Richard	Rina	Rafael	Rebekah	Rene	Rose
Shary	Sean	Sara	Sebastien	Sally	Sam
Tobias	Tammy	Tony	Tanya	Teddy	Teresa
Virginie	Vince	Valerie	Van	Vicky	Victor
Walter	Whitney	William	Wendy	Wilfred	Wanda

How is the strength of hurricanes ranked?

Hurricane Irma is a Category 5 storm

In brief | How tropical cyclones are ranked

The Saffir-Simpson Hurricane Wind Scale is used to rank tropical cyclone wind strength in many parts of the world.

Category	Sustained wind speed	Expected damage
1	74 to 95 mph	Damage to roofs and gutters. Large branches will snap. Extensive damage to power lines and poles
2	96 to 110 mph	Major damage to roofs. Shallow-rooted trees will be snapped or uprooted. Near-total power loss
3	111 to 129 mph	Major damage to homes. Trees will be snapped or uprooted, blocking roads. Electricity and water unavailable
4	130 to 156 mph	Severe damage to homes. Most trees will be snapped or uprooted and power poles downed. Most of the area uninhabitable
5	157 mph +	Catastrophic damage to homes. Most of the area will be uninhabitable for weeks or months

Effects of hurricanes

The effects of hurricanes can be grouped into two: weather and economic.

Impact on the weather

Storm Surge

Hurricanes bring about storm surges. The powerful spiral wind action carries water a couple of feet high and lashes it ashore. This can destroy structures and items very close to the shore. Storm surges are the main causes of the floods they bring.

What is a Storm surge: This is a rise in the ocean's water level as a result of extreme winds blowing over the sea's surface. Water levels can rise up to 15 feet and a lot more. As the storm makes a landfall, the high sea level brings water inland, causing major flooding and destruction.

Floods

Hurricanes carry a lot of rains with it and even after the hurricane has subsided, it may continue to rain. This causes a lot of floods and brings about other types of destructive results.

Winds

Houses, cars, farms, and many other structures are blown away by the powerful winds that come with hurricanes.

Impact on the economic

Anytime there is a disaster caused by a natural phenomenon like hurricanes, floods and fires, there is extensive damage to property. Peoples' livelihoods are wiped away and may take many years to get things together again. In many cases, there are fatalities and entire communities are severely affected.

People may be forced to stay home for so long and businesses suffer as a result.

In addition to that, the state (or governments) spend huge amounts of resources in preparation for these occurrences. Emergency work and rebuilding of infrastructure cost the city a lot of money. It is known that hurricane Sandy caused about 50 billion USD worth of damage to the people of the United States of America.

Deadliest tropical cyclones in Pakistan

Cyclones mostly hit the Sindh coast than the Balochistan coast in Pakistan. During the last 100 years a number of cyclonic storms have struck Pakistan's costal areas. The years involved were 1895, 1902, 1907, 1944, 1948, 1964, 1985, 1999, 2007 and 2010.

Cyclones that effect Pakistan lose much of their intensity by the time they reach country's coastline. Following are the deadliest cyclones in Pakistan's history, these cyclones caused fatalities greater than 100.

1965 Karachi cyclone

Not much is known about this cyclone but it is the deadliest tropical storm in the history of Pakistan as it caused 10,000 casualties in Karachi on 15 December.

Cyclone 2A 1999

This cyclone is the strongest and most intense cyclone in the history of Pakistan. A category 3 hurricane, it killed 6200 people in the country and made landfall in Shah Bandar at peak intensity on 20 May near Karachi city in Sindh province.

Cyclone Yemyin

It killed 200 people alone in Karachi city on 23 June due to heavy rainfall and intense windstorms of 70 mph. It made landfall near the towns of Ormara and Pasni in the Balochistan province on 26 June where it killed 300 people. Overall it killed 730 people and affected the lives of 2 million people in Pakistan making it the third deadliest cyclone in the history of the country.

1993 Pak-Indo cyclone

A category 1 hurricane, it weakened over the sea near Sindh-Gujarat border due to high wind shear. However it caused massive rainfall and flooding in Karachi but Thatta and Badin districts were the worst affected where the cyclone killed 609 people and displaced some 200,000 others.

1964 Indus valley cyclone

It made landfall in Tharparkar and Hyderabad district in Sindh province in Pakistan on 12 June. However it caused a great loss of life and property in the province. It killed 450 people and left some 400,000 people homeless.

Tropical cyclones names

Tropical cyclones passing over the northern part of the Indian Ocean are named by eight countries in the region, namely India, Pakistan, Bangladesh, Sri Lanka, Maldives, Myanmar, Oman and Thailand. The process only began in 2004, fours years after World Meteorological Organization agreed in principle to allow them to name cyclones originating in the Bay of Bengal and Arabian Sea. The alphabet system is used to designate the name of a cyclone, which means the name of the year's first cyclone begins with A. Previously, till 1979, cyclones were only given female names. Male names were only introduced in the same year. World Meteorological Organization (WMO) maintains the database of cyclone/hurricane/typhoon names. There are six lists of names used in rotation and they are recycled every six years. The names are picked from this pre-designated list and are usually familiar with the people living in the region. India has so far contributed the following names: Agni, Bijli, Akash, Jal, Lehar, Megh, Sagar and Vayu

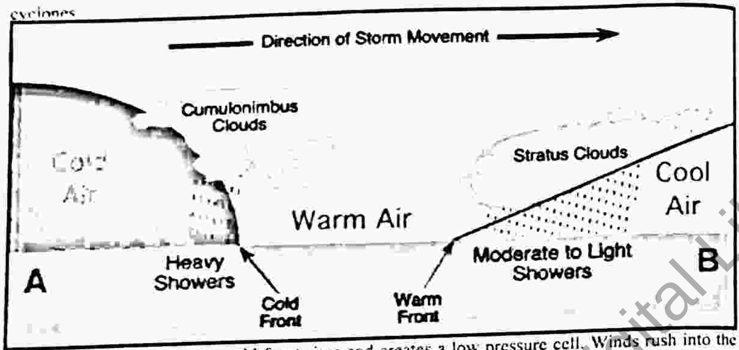
List of Northern Indian Ocean tropical cyclone names

	Bangladesh	India	Maldives	Myanmar	Oman	Pakistan	Sri Lanka	Thailand
1	Onil	Agni	Hibaru	Pyarr	Baaz	Fanoos	Mala	Mukda
	Ogni	Akash	Gonu	Yemyin	Sidr	Nargis	Rashmi	Khai-Muk
3	Nisha	Bijli	Aila	Phyan	Ward	Laila	Bandu	Phet
4	Giri	Jal	Keila	Thane	Murjan	Nilam	Viyaru	Phailin
5	Helen	Lehar	Madi	Nanauk	Hudhud	Nilofar	Ashobaa	Komen
6	Chapala	Megh	Roanu	Kyant	Nada	Vardah	Maarutha	Mora
7	Ockhi	Sagar	Mekunu	Daye	Luban	Titli	Gaja	Phethai
8	Fani	Vayu	Hikaa	Kyarr	Maha	Bulbul	Pawan	Amphan

The Mid-Latitude Cyclone

Cyclones can be the most intense storms on Earth. A **cyclone** is a system of winds rotating counterclockwise in the Northern Hemisphere around a low pressure center. The swirling air rises and cools, creating clouds and precipitation.

Mid-latitude cyclones form at the polar front when the temperature difference between two air masses is large. These air masses blow past each other in opposite directions. Coriolis effect deflects winds to the right in the Northern Hemisphere, causing the winds to strike the polar front at an angle. Warm and cold fronts form next to each other. Most winter storms in the middle latitudes, including most of the United States and Europe, are caused by mid-latitude cyclones.



The warm air at the cold front rises and creates a low pressure cell. Winds rush into the low pressure and create a rising column of air. The air twists, rotating counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Since the rising air is moist, rain or snow falls.

Mid-latitude cyclones form in winter in the mid-latitudes and move eastward with the westerly winds. These two- to five-day storms can reach 1,000 to 2,500 km (625 to 1,600 miles) in diameter and produce winds up to 125 km (75 miles) per hour.

The Stages of Mid-Latitude Cyclones

In the early 1900s, Norwegian meteorologists developed the first models for the life cycle of mid-latitude cyclones. Also known as wave cyclones, extra-tropical cyclones or baroclinic storms, mid-latitude cyclones tend to form between 30 degrees and 50 degrees of latitude during the winter months and develop into massive, spiraling storms that can grow up to approximately 1,000 miles wide.

Cyclogenesis

During the initial stage of the cyclone's life cycle, also known as cyclogenesis, a boundary separates opposing fronts of cold and warm air. When an upper-level disturbance moves over the front, it causes a wave to form. Cyclonic shear begins to occur when the warm and cold fronts slide against one another, generating the spinning motion characteristic of cyclones. The meeting of cold and warm air creates precipitation, which is heaviest near the border of the front.

Mature Stage

During the cyclone's mature stage, the wave formed during the initial phase grows as warm air replaces the space left behind by the moving cold front, and the organization of both the cold and warm fronts increases. The cold front moves faster than the warm front, intensifying the cyclonic circulation. The system's lowest pressure is located at the center of the wave, and the cyclone's winds are strongest about eight miles above ground.

Occluded Stage

In the mid-latitude cyclone's third stage, the denser cold front catches up with the warm front. Because the warm air isn't dense enough to displace the cold air ahead of it, it shifts up and slides above the cold air in its path. This action eventually forms an occluded front, in which the wave transforms into a loop, which is narrower at its base and cuts off the supply of warm air.

Dissolving Stage

The final stage of the cyclone occurs when the loop formed by the cold front boundary surrounding the low-pressure pocket of warm air closes. This cuts off the supply of warm moist air and the lifting force caused by the interaction between the cold and warm fronts. The loss of the convergence and uplift mechanisms cause the cyclone to dissolve, and the low pressure system gradually stabilizes.

Difference between Hurricanes and Mid-Latitude Cyclones

- Hurricanes are large storms that originate in the tropics with sustained winds (winds averaged over a two-minute period) greater than 74mph. On the other hand, a mid-latitude cyclone (MLC) is a larger storm that forms in the middle and high latitudes.
- Both of these storm systems get their fuel in very different ways. A hurricane gets its energy from the warm waters of the tropics from the latent heat of condensation. In technical speak; latent heat is the amount of energy used to change a substance from one phase of matter to another. For example, the phase change water goes through to turn into steam (a liquid to a gas). MLC's derive their energy from horizontal temperature changes, such as a cold front passing over an area. If you look at a cross-section of a hurricane, there is a centralized column of air that is warmed from the surface as it lifts upwards. Thus, hurricanes are also known as warm-core lows. MLC's, in contrast, are cold-core lows that will intensify with increasing height.
- A hurricane usually contains an eye, which is where sinking air occurs (hence the sometimes clear skies in the eye itself). In contrast, MLC's have centers where air rises. Hurricane winds are the strongest at the surface, whereas the strongest winds produced by an MLC are aloft, typically found in the jet stream.
- Other differences can be seen on a surface chart; the more isobars (lines of equal pressure), the greater the change in pressure (pressure gradient) and the faster the winds will be. Also, hurricanes do not have the fronts (warm and cold) that are signature of an MLC.
- The similarity between these two types of storms; both are surface areas of low pressure with winds moving in a counter-clockwise direction (if you are in the northern hemisphere).
- Speaking of hemispheres, you can have an MLC in the southern hemisphere but a hurricane is solely a northern hemisphere storm (called a hurricane in the Atlantic, Caribbean, central and northeastern Pacific). In the northwestern Pacific, we end up with a typhoon, and in the Bay of Bengal (Indian Ocean) or the Arabian Sea…a cyclone.

TORNADO

THE MOST DEADLY AND DESTRUCTIVE WIND

What is a Tornado?

Tornadoes are violent storms that strike as a powerful rotating mixture of wind and thunderstorm clouds, extending from the clouds to the ground in a funnel shape. They are known to be the most powerful and destructive atmospheric generated phenomena (wind systems), and are very common in the USA, particularly from the middle belt extending to the east coast.

Every year, there is an average of 800 tornadoes that hit various parts of the USA. Even though many of them are very mild and could be seen as just strong winds, there has been a few tornadoes that have been very devastating and flattened many homes, schools and structures along its path.

How do toraadoes form?

Tornadoes are formed when the center of a big storm cloud starts to rotate. As it forms, it extends downwards until it hits the ground.

Tornado incidents are distributed all year through, forming particularly in late spring (March), with the most incidents occurring in the summer (May and June), and reducing in numbers and strengths in the fall.

FUJITA (FOO-GEE-TAH)

A scale based on the SEVERITY and DAMAGE the TORNADO made

Tornado features:

Tornadoes occur usually during the daytime, from mid-afternoon till about early evening. Their movement is usually from the southwest to the northeast. Sometimes they move in any direction, and in the general path of the thunderstorm. The spinning winds cover an area of about 300 — 400 yards, and can travel on a path for about 5 miles (some tornadoes travel for over 80 miles), at a speed of about 5 — 60mph.

Damage from a EF1 tornado

Moderate Damage, broken windows, loss of exterior doors, scratched roof

Sometimes tornadoes develop in a very short time frame, leaving very little lead time for warning and preparation.

Damage from a EF5 tornado

Huge Damage, cars flying, houses destroyed, lots of deformation.

How do Tornadoes form?

This question is one that has not been a bit uncertain among people who study weather, but here is an explanation that many believe is the closest possible cause of tornadoes.

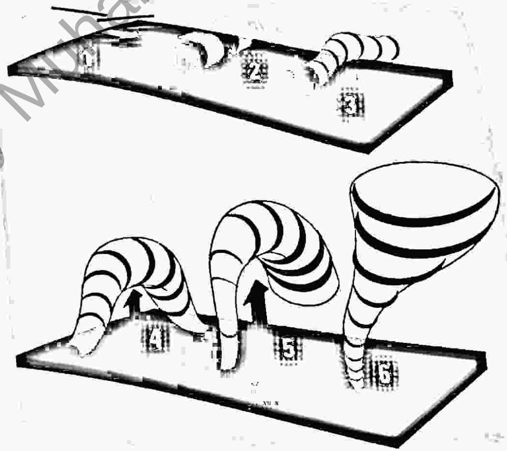
Tornadoes are simply borne out of supercell storms (Supercell tornadoes are more powerful than those that do not come from supercells). A supercell storm is a thunderstorm characterized by powerful updrafts. Example of non-supercell tornadoes are '***gustnadoes***' and '***landspouts***'.

FACTS

Usually a tornadoes color matches the color of the ground.

Here is how they form:

Take a look at this illustration and find the notes on next page.



Step 1: Like all winds and storms, tornadoes begin when the sun heats up the surface of the land. As the warm, less heavy air begins to rise, it meets the colder, heavier air above it. Note that wind shears make it even easier to set them off. A wind shear is when two winds at different levels and speeds above the ground blow together in a location.

Step 2: The faster moving air begins to spin and roll over the slower wind. As it rolls on, it gathers pace and grow in size.

Step 3: At this stage, it is an invisible, horizontal wind spinning and rolling like a cylinder. As the winds continue to build up, stronger and more powerful warm air forces the spinning winds vertically upward, causing an updraft.

Step 4: With more warm air rising, the spinning air encounters more updraft. The winds spin faster, vertically upwards, and gains more momentum.

Step 5: At this stage, the spinning winds, creates a vortex and the wind has enough energy to fuel itself.

Step 6: The tornado is fully formed now and moving in the direction of the thunderstorm winds. When the pointed part of the tornado touched the ground from the cloud, it is often referred to as 'touch down'. As it moves it rips off things along its patch.

Tornadoes in Pakistan

Tornadoes are highly uncommon in Pakistan, they mostly occur during the spring season that is March and April usually when a Western Disturbance starts effecting the northern parts of the country. It is also speculated that cycles of tornado years may be correlated to the periods of reduced tropical cyclone activity. Following is a list of tornadoes which struck the country.

- On **10 March 1981**, a killer tornado killed some 56 people and injured 600 people in Gujranwala and Sheikhupura districts of Punjab province.
- On **10 March 1985**, a tornado killed 18 people in the northern areas of the country.
- In **1995**, hundred people were reported to have been killed by a tornado in Pakistan.
- On **28 March 2001**, a killer tornado killed 10 people and injured some 100 people in Chak Misran village near Bhalwal area in Punjab province. The tornado had surface winds greater than 75 mph. It uprooted electric poles and bill boards in the area.
- On **12 October 2006**, a tornado formed near Rawalpindi in Punjab.
- Another Tornado hit Narang Mangi near Narowal city in Punjab province but no relevant data is available about this tornado.

Disaster Risk Management

When a hazard event (*such as a drought, flood, cyclone, earthquake or tsunami – among others*) strikes a community, triggering the loss of, or harm to life and the destruction or damage of infrastructure, it highlights the fact that the society and its assets are vulnerable, i.e. susceptible to the impacts of hazard events. In the context of disaster-risk reduction, the disaster makes the following facts evident:

The geographical area where the community is settled is exposed to such a hazard;

The society (*including individuals*) and its infrastructure, assets and other processes - as well as services which experienced damage or destruction - are vulnerable.

Disaster Risk

According to the terminology of UNISDR, disaster-risk is defined as "the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, and capacity". In the technical sense, it is defined in terms of the combination of three terms: hazard, exposure and vulnerability.

For instance, when a settlement is established on the shores of a river, by carrying out a hydraulic analysis, hydrologists can identify and characterise the flood hazard. According to the UNISDR definiton, a "hazard is characterised by its location, intensity or magnitude, frequency and probability". In some countries, such hazard areas outline the geographic extent of floods which have a 100 year period of return. Any people, assets and infrastructure; as well as ecosystems located inside the area, are exposed to floods. The degree of damage is then characterised by its vulnerability. For instance, this can be defined by the physical structure of a building, as well as to include social and economic characteristics of a system. Additionally, vulnerability is further characterised by the capacities of a society to cope with a hazard.

Definitions and Terminology

- **Hazard** is defined as "a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or

environmental degradation". Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its "location, intensity or magnitude, frequency and probability".

- **Exposure** is defined as "the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas". As stated in the UNISDR glossary, "measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest".
- **Vulnerability** is defined as "the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards". Vulnerability is multi-dimensional in its nature, and next to the four dimensions above, some authors also include cultural and institutional factors. Examples include, but are not limited to, poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, high levels of poverty and education, limited offical recognition of risks and preparedness measures, disregard for wise environmental management or weak institutions, and governance (e.g. including corruption etc.).
- **Disaster-risk Reduction** "is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development". The UNISDR definition further annotates that "disaster risk reduction is the policy objective of disaster risk management, and its goals and objectives are defined in disaster risk reduction strategies and plans".
- Disaster-risk Reduction strategies and policies define goals and objectives across different timescales, with concrete targets, indicators and time frames.
- **Disaster-risk Management** is the application of disaster risk reduction policies and strategies, to prevent new disaster risks, reduce existing disaster risks, and manage residual risks, contributing to the strengthening of resilience and reduction of losses. Disaster risk management actions can be categorized into; prospective disaster risk management, corrective disaster risk management and compensatory disaster risk management (*also referred to as residual risk management*).
- **Information management in Disaster-risk Reduction**
- In recent years, researchers and experts have been developing methods to conduct the assessment of hazards, vulnerability, and coping capacities; as well as techniques to combine such assessments in order to present them in risk map format. Such maps are essential in developing strategies to reduce the level of existing risks, and as a way to avoid a generation of new risks due to underlying social and economic risk drivers.

The UN and Disaster-risk Reduction

Since the beginning of the 1990s, the United Nations has been promoting efforts to change the paradigm of disasters, advocating for the incorporation of disaster-risk reduction, efforts worldwide as a way to reduce the effects of natural hazards on vulnerable communities. In 2015, UNISDR facilitated the negotiations amongst Member States, experts and collaborating organizations; which led to the adoption of the **Sendai Framework for Disaster Risk Reduction 2015-2030**. Between 2015 and 2030, Member States around the world will conduct a variety of efforts within the context of the **four Priority Areas** contained in the Sendai Framework, as a way to reduce risks with the goal of minimizing losses due to the manifestation of hazards of natural origin. The four Priority Areas are:

Priority 1: Understanding disaster risk;
Priority 2: Strengthening disaster risk governance to manage disaster risk;
Priority 3: Investing in disaster risk reduction for resilience;
Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

National Disaster Management Authority (NDMA) Pakistan

Pakistan faces risk of almost all types of natural disasters and multitude of man-made hazards. Traditionally the country is vulnerable to wide-ranging hazards like floods, earthquakes, landslides, droughts, cyclones, industrial/technical accidents etc. In the recent years, terrorism related disasters are causing colossal loss of human life and material. Pakistan, being densely populated country with a large percentage living below the poverty line, whenever struck with a disaster, suffers heavy loss.

A report recently prepared by the National Disaster Management Authority (NDMA) says Pakistan's position on the global climate risk index has climbed up two levels making it the eighth on the list of the countries prone to natural and manmade disasters.

Pakistan, primarily due to its geographic location and topographical layout, faced extreme environmental and climatic challenges. Those challenges gave rise to a multitude of hazards which included hydro-meteorological, seismic and manmade

Pakistan was ranked 10th earlier on global climate risk index and has now upped two levels to eighth after Honduras, Myanmar, Haiti, Philippines, Nicaragua, Bangladesh and Vietnam.

In Pakistan the monsoon rainfall zone had shifted 100 kilometres from east to west, which was hugely significant. Some 143 disaster events had been recorded in Pakistan in the past 20 years, which caused losses of 3,931.4 million dollars which equalled 0.7pc of GDP. Pakistan's ratio of deaths on 100,000 population was calculated at 0.32.

After the deadly October 8, 2005 earthquake that rocked Pakistan, the need for a single, competent authority to respond, rehabilitate and reconstruct damaged areas became an urgent need of the hour. The Government of Pakistan, in realization of this need, introduced the National Disaster Management Ordinance 2007 which effectively became a law in 2010 under the National Disaster Management Act. NDMA acts as a coordination and monitoring agency for relief efforts between and among armed forces, civilian rescue agencies, emergency teams and United Nations.

As mentioned in the opening lines, NDMA defines "disaster" as "a catastrophe or a calamity in an affected area, arising from natural or man-made causes or by accident which results in a substantial loss of life or human suffering or damage to, and destruction of, property." (Ref: Section 2 (b) in NDMA Act 2010). Whereas "disaster management" has been defined as, "managing the complete disaster spectrum, including (i) preparedness; (ii) response; (iii) recovery and rehabilitation; and (iv) reconstruction" (Ref. Section 2 (c) in NDMA Act 2010).

The NDMC is headed by the prime minister while the AJK prime minister, the leaders of the opposition in the National Assembly and Senate, ministers of defence, foreign affairs, social welfare, finance and interior, the governor of KP, all the chief ministers, civil society representatives and the chairman NDMA are its members.

October 8th 2017
Pakistan's First National Disaster Awareness Day

1935 Quetta earthquake About 60,000 people were killed in one of the deadliest earthquakes to hit South Asia when a 7.7 Richter scale earthquake virtually leveled the city of Quetta in Balochistan on May 31. The epicenter was about 153km from the city.

1945 Balochistan tsunami On November 28 a massive earthquake off the Makran coast generated a destructive 40-foot tsunami in northern Arabian Sea causing the death of 4,000 people. The epicentre was 98km southwest of the town of Pasni.

1950 floods An estimated 2,900 people were killed and over 100,000 homes were destroyed leaving 900,000 people homeless during the monsoon season and resulting floods in 1950 in Punjab. The worst hit was the city of Lahore where the Ravi River flooded.

1970 East Pakistan cyclone A tropical cyclone struck the former East Pakistan (Bangladesh) on November 12, 1970. It was the deadliest cyclone ever recorded in East Bengal that left around 500,000 people dead, primarily as a result of the storm surge that flooded much of the low lying islands of the Ganges delta.

1974 Hunza earthquake On December 28, 1974, a 6.2 Richter scale earthquake hit Swat, Hunza and Hazara areas in northern Pakistan. About 5,300 people were killed, 17,000 were injured and 97,000 were affected. Landslides and rock falls contributed to the damage. Most of the destruction centred around the village of Pattan about 160km north of Islamabad.

2000 drought At least 1.2 million people in Balochistan were affected by drought and over 100 died, mostly because of dehydration. Millions of animals perished. One of the worst hit areas was the town of Nushki, close to the border with Afghanistan.

2005 Kashmir Quake On October 8, 2005, a 7.6 Richter scale quake struck the Kashmir region and parts of north-western Pakistan. At least 73,000 people were killed and more than 3.3 million were made homeless. The worst affected areas included Neelum Valley and Bagh district in AJK and Mansehra division. The collapse of a high rise apartment building in Islamabad also killed scores.

2007 Cyclone Yemyin At least 730 people died as a result of flash floods triggered by Cyclone Yemyin, which struck coastal areas of Sindh and Balochistan in early July 2007. Some 350,000 people were displaced, 1.5 million were affected and more than two million livestock perished.

2010 Hunza Lake Disaster A landslide in January 2010 at Attabad village in the Hunza Valley killed 20 people which led to around 40 houses sliding into the Hunza river. Debris from the landslide caused the river to dam, leading to the formation of a large lake which threatened to flood downstream areas. Some 20,000 were forced to leave their homes by June. The lake is still there, having washed away a sizable portion of the Karakoram Highway and several houses.

Pakistan Floods 2010 In the worst ever floods that affected the whole of Pakistan around 2,000 people lost their lives and over 20 million were affected. Pakistan sought international help as the country was unable to cope with the catastrophe on its own.

ENERGY RESOURCES

Energy Resources

Energy is the capacity of a physical system to perform work. Energy exists in several forms such as heat, kinetic or mechanical energy, light, potential energy, electrical, or other forms. The **SI** unit of energy is the joule (J) or newton-meter (N * m). The joule is also the SI unit of work.

Difference *between* **Energy** *and* **Power**

In physics, ***energy*** is defined as *the amount of work that can be performed by force,* whereas ***power*** is defined as *the rate at which work is performed.*

	Energy	Power
Key difference:	Energy is the capacity for doing work. It is the measure of how much fuel is contained within something, of how much work can it accomplish. It is the amount of power consumed in accomplishing work.	Power, is the rate at which energy is used or consumed. It is the rate at which the work is accomplished. Essentially power is the energy used over time
Unit:	joules = watt-seconds	watts = joules/second
Definition:	Energy is the capacity to do work. Energy is power integrated over time.	Power is the rate at which work is done, or energy is transmitted.
Example:	I left a 100 W light bulb on for 30 days, which raised my electric bill by 72 kWh (kilowatt-hours).	A car's battery can provide 500 amps at 12 volts, which equals 6kW of power.

Forms of Energy (CSS 2011)

Energy comes in two basic forms: potential and kinetic.

Potential Energy is any type of stored energy; it isn't shown through movement. Potential energy can be **chemical**, **nuclear**, **gravitational**, or **mechanical**.

Kinetic Energy is the energy of movements: the **motion** of objects (from people to planets), the vibrations of **atoms** by **sound waves** or in **thermal** energy (heat), the **electromagnetic** energy of the movements of light waves, and the motion of electrons in **electricity**.

Each form of energy can be transformed into any of the other forms, but energy isn't destroyed or created. Losses of energy can always be accounted for by small transformations to other types of energy, like sound and heat. Power plants convert potential energy or kinetic energy into **electricity**, a type of kinetic energy, and electricity in turn can be converted back into other forms of energy, like heat in an oven or light from a lamp.

Kinetic Energy

It is a matter of common experience that a fast moving stone can break a windowpane, falling water can rotate turbines and moving air can rotate windmills and propel sailboats. In all these examples, the moving body possesses energy. Work is done by the body in motion. This type of energy possessed by moving objects, is known as kinetic energy

Kinetic energy is defined as the energy possessed by an object by virtue of its motion. Kinetic energy is represented by the letter "T". All moving objects possess kinetic energy.

Kinetic Energy Formula

Kinetic energy of an object *i.e.*

- Kinetic Energy = The work done to set the object in motion from rest at a specified velocity.
- Kinetic Energy = Change in the velocity of the object under motion of a different velocity.

Let us consider, an object of mass '**m**' is at rest and given an acceleration '**a**' to set a velocity of '**v**' within a time '**t**'. The distance '**s**' moved by the object in that time is the product of the average velocity and time.

Distance S = Average Velocity × time.

In other words,

$S = v-02 \times t = vt2.$

The force F required to set the object In motion as per above condition is given by,

$F = ma = mvt$

Hence, the work W done for this motion is

$W = F_s = mvt \times vt2$

$= 12\ mv^2$

As per the definition of kinetic energy, this is the kinetic energy E acquired by the object

$E = 12\ mv^2$

This is called as the **Kinetic Energy Equation** also called kinetic energy formula.

Potential Energy

Water stored in a reservoir is capable of rotating turbines, which are kept at a lower level *i.e;* water stored in a reservoir possesses energy.

The Potential Energy definition of an object is better explained as the energy acquired by it by virtue of its position and an energy which is readily available for use. A potential energy in an object created by the work done by a force on it.

Thus potential energy can be defined as:

An energy acquired by an object by virtue of its position is called its potential energy.

Formula of Potential energy, is P.E = mgh

Where m = mass of the body,

h is the height attained due to the body's displacement and

g is the acceleration due to gravity which is constant on earth.

Potential energy formula helps to calculate the mass, height or potential energy if any of the two quantities are given. It is expressed in Joules.

Potential Energy	Kinetic Energy
Chemical Energy is energy stored in the bonds of atoms and molecules. Batteries, biomass, petroleum, natural gas, and coal are examples of stored chemical energy. Chemical energy is converted to thermal energy when we burn wood in a fireplace or burn gasoline in a car's engine	**Radiant Energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Sunshine is radiant energy, which provides the fuel and warmth that make life on Earth possible.
Mechanical Energy is energy stored in objects by tension. Compressed springs and stretched rubber bands are examples of stored mechanical energy	**Thermal Energy** or heat is the vibration and movement of the atoms and molecules within substances. As an object is heated up, its atoms and molecules move and collide faster. Geothermal energy is the thermal energy in the Earth
Nuclear Energy is energy stored in the nucleus of an atom — the energy that holds the nucleus together. Very large amounts of energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms in a process called **fusion**.	**Motion Energy** is energy stored in the movement of objects. The faster they move, the more energy is stored. It takes energy to get an object moving, and energy is released when an object slows down. Wind is an example of motion energy. A dramatic example of motion is a car crash, when the car comes to a total stop and releases all its motion energy at once in an uncontrolled instant
Gravitational Energy is energy stored in an object's height. The higher and heavier the object, the more gravitational energy is stored. When you ride a bicycle down a steep hill and pick up speed, the gravitational energy is being converted to motion energy. Hydropower is another example of gravitational energy, where the dam "piles" up water from a river into a reservoir.	**Sound** is the movement of energy through substances in longitudinal (*compression/rarefaction*) waves. Sound is produced when a force causes an object or substance to vibrate — the energy is transferred through the substance in a wave. Typically, the energy in sound is far less than other forms of energy
	Electrical Energy is delivered by tiny charged particles called electrons, typically moving through a wire. Lightning is an example of electrical energy in nature, so powerful that it is not confined to a wire

Difference *between* Kinetic Energy *and* Potential Energy

Kinetic Energy	Potential Energy
Definition: The energy of a body or a system with respect to the motion of the body or of the particles in the system.	Potential Energy is the stored energy in an object or system because of its position or configuration.
Relation to environment: Kinetic energy of an object is relative to other moving and stationary objects in its immediate environment	Potential energy is not relative to the environment of an object.
Transferability: Kinetic energy can be transferred from one moving object to another, say, in collisions.	Potential energy cannot be transferred.
Examples: Flowing water, such as when falling from a waterfall.	Water at the top of a waterfall, before the precipice.
SI Unit: Joule (J)	Joule (J)
Determining factors: Speed/velocity and mass	Height or distance and mass

Energy and its Conservation

The conservation of matter and energy means that the total amount of energy and the total amount of matter is always constant in a given closed, isolated system. In other words, neither energy nor mass can be created or destroyed in any physical or chemical process.

Albert Einstein pointed out that matter and energy are the same thing, and matter can be converted to energy. Thus, if energy is being "produced" in a nuclear reaction, although the total calculated amount of energy is increasing, but since the calculated amount of mass is decreasing, and matter and energy are the same thing, therefore the total energy of the system can be regarded as constant.

Thus, the law of conservation of energy and the law of conservation of matter were combined, to form the law of conservation of matter and energy. Note that the term "Law of conservation of energy" implies the law of conservation of matter and energy

Types *of* Energy Sources

The energy sources have been split into three categories: fossil fuels, renewable sources, and nuclear sources. The fossil fuels covered here are coal, petroleum, and natural gas. The renewable energy sources are solar, wind, hydroelectric, biomass, and geothermal power. The nuclear-powered sources are fission and fusion.

Fossil Fuels

Fossil fuels have been a widely used source of energy every since the Industrial Revolution just before the dawn of the 20th century.

The theory behind fossil fuels is actually quite simple. Burning coal, natural gas, and petroleum releases energy stored in the fuel as heat. The energy contained by the fuels is derived from the energy of the sun

The heat that is recovered upon combustion of the fuel can be used by us in several ways. Industrial processes that require extremely high temperatures may burn a great deal of very pure coal known as "coke" and use the energy released to directly heat a system. Some people make use of clean burning natural gas to heat their homes. Combustion of fossil fuels can also be used to generate electricity; the fuel is burned to heat water, and the steam from the boiling water spins turbines that power a generator, thereby manufacturing electricity

Coal

About 300 million years ago, enormous ferns and other prehistoric plants and animals were common on the swamp-like earth. When those plants and animals died and fell to the ground, they were covered with water and they slowly decomposed. As decomposition took place in the absence of oxygen, much of the hydrogen content of the matter was eroded away, leaving a material rich in carbon. The material was compressed over the years by sand and dirt, leaving the form of carbon known as coal. Coal can be burned to provide a source of heat that can be used for heating homes or for industrial processes including generating electricity. Coal can also be gasified by heating it in an oxygen free atmosphere. The "coal-gas" produced in this way can also be burned to provide a source of heat. As decomposition took place in the absence of oxygen, much of the hydrogen content of the matter was eroded away, leaving a material rich in carbon. The material was compressed over the years by sand and dirt, leaving the form of carbon known as coal. The theory that fossil fuels formed from the fossilized remains of dead plants by exposure to heat and pressure in the Earth's crust over millions of years was first introduced by Georg Agricola in 1556 and later by Mikhail Lomonosov in the 18th century.

The nature of coal is such that the higher the carbon content, the more cleanly and brilliantly the coal burns. Thus "peat", which is the state of the decomposing plants before being compressed, is a weak, impure substance. The other states of coal, from lowest carbon content to highest, are "lignite," bituminous coal, and anthracite coal. If the coal is heated and compressed even more, the result is "graphite," almost completely pure carbon.

Nearly all the different forms of coal are used in some way or another. For instance, peat has been used for burning in furnaces, whereas bituminous coal is used extensively for the generation of electricity. "Coke," a very pure form of coal with a high heat content is used primarily in the steel industry, where high temperatures are required.

Natural Gas

Natural gas is almost always found with deposits of petroleum oil. When the oil is pumped from oil wells, the natural gas is also recovered. Wells with only natural gas also exist. Natural gas can be burned to provide a source of heat; it can also be used as a fuel for internal combustion engines and combustion turbines. Compressed Natural Gas (CNG) vehicles are becoming more popular and most of the new electricity generation power plants use natural gas as their main fuel.

Petroleum

Petroleum, or "crude oil," is a liquid fuel that is present in various locations throughout the world. It has many uses, from the generation of electricity to the manufacture of medicines, plastics, and other commercial items. Much like coal, petroleum is formed from the remains of biodegraded organic material. When animals that lived in the sea millions of years ago died underwater, their remains were gradually covered by layers of very fine dirt known as "silt" on the ocean floor. Then, as the years passed, pressure from the layers built up and compressed the organic material, forming the oil.

Petroleum has many different "viscosities," or thicknesses. The viscosity depends on the amount of gases and solids that are present in the oil. Often, natural gas is dissolved in the liquid and can be extracted for other uses. Petroleum take three main forms: paraffin, asphaltic, and mixed-base. These forms are based upon the chemical makeup of the hydrocarbon-based oil.

Renewable Energy

(CSS 2011/2008/2013)

Renewable energy is a socially and politically defined category of energy sources. Renewable energy is generally defined as energy that comes from resources which are continually replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat.

About 16% of global final energy consumption comes from renewable resources, with 10% of all energy from traditional biomass, mainly used for heating, and 3.4% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 3% and are growing rapidly.

The share of renewables in electricity generation is around 19%, with 16% of electricity coming from hydroelectricity and 3% from new renewables. Most of the renewable energy in Pakistan comes from hydroelectricity. Pakistan has much to offer Asia with regards to wind energy. In recent years, the government has completed several projects to demonstrate that wind energy is viable in the country. In Mirpur Sakro, 85 micro turbines have been installed to power 356 homes. In Kund Malir, 40 turbines have been installed, which power 111 homes. The Alternative Energy Development Board (AEDB) has also acquired 18,000 acres for the installation of more wind turbines.

Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services:

- **Power generation.** Renewable energy provides 19% of electricity generation worldwide. Renewable power generators are spread across many countries, and wind power alone already provides a significant share of electricity in some areas: for example, 14% in the U.S. state of Iowa, 40% in the northern German state of Schleswig-Holstein, and 49% in Denmark. Some countries get most of their power from renewables, including Iceland (100%), Norway (98%), Brazil (86%), Austria (62%), New Zealand (65%), and Sweden (54%).
- **Heating.** Solar hot water makes an important contribution to renewable heat in many countries, most notably in China, which now has 70% of the global total (180 GWth). Most of these systems are installed on multi-family apartment buildings and meet a portion of the hot water needs of an estimated 50–60 million households in China. Worldwide, total installed solar water heating systems meet a portion of the water heating needs of over 70 million households. The use of biomass for heating continues to grow as well. In Sweden, national use of biomass energy has surpassed that of oil. Direct geothermal for heating is also growing rapidly.
- **Transport fuels.** Renewable biofuels have contributed to a significant decline in oil consumption in the United States since 2006. The 93 billion liters of biofuels produced worldwide in 2009 displaced the equivalent of an estimated 68 billion liters of gasoline, equal to about 5% of world gasoline production

Mainstream Renewable Technologies

LED Energy

LEDs are two way semiconductor light source. It can also be called pn junction diode. The light-emitting diode (LED) is one of today's most energy-efficient and rapidly-developing lighting technologies. Quality LED light bulbs last longer, are more durable, and offer comparable or better light quality than other types of lighting.

In 1962 while working for General Electric, Nick Holonyak, Jr., invented the first visible-spectrum LED in the form of red diodes. Pale yellow and green diodes were invented next. As companies continued to improve red diodes and their manufacturing, they began appearing as indicator lights and calculator displays in the 1970s. The invention of the blue diode in the 1990s quickly led to the discovery of white LEDs – researchers simply coated the blue diodes with a phosphor to make it appear white. Shortly thereafter, researchers demonstrated white light using red, green and blue LEDs. These breakthroughs led to LEDs being used in a variety of applications including traffic lights, flashlights and TVs.

Wind Power

Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use; the power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically up to the maximum output for the particular turbine. Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms. Typical capacity factors are 20-40%, with values at the upper end of the range in particularly favourable sites. Globally, the long-term technical potential of wind energy is believed to be five times total current global energy production, or 40 times current electricity demand, assuming all practical barriers needed were overcome. This would require wind turbines to be installed over large areas, particularly in areas of higher wind resources, such as offshore. As offshore wind speeds average ~90% greater than that of land, so offshore resources can contribute substantially more energy than land stationed turbines.

Hydropower

Energy in water can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy. There are many forms of water energy:

- Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams. Examples are the Tarbela Dam , Warsak Dam , Mangla Dam etc
- Micro hydro systems are hydroelectric power installations that typically produce up to 100 kW of power. They are often used in water rich areas as a remote-area power supply (RAPS).
- Run-of-the-river hydroelectricity systems derive kinetic energy from rivers and oceans without the creation of a large reservoir.
- Tidal energy is another form of hydro-power. Tidal power, sometimes also called tidal energy, is the form of hydro-power that converts the energy of tides into electricity. The coastline of Pakistan, which is about 1,045km-long with dominant features, is the best resource for harnessing tidal energy. The world's first large-scale tidal power plant (the Rance Tidal Power Station, France) became operational in 1966

Solar Energy

Solar energy applies energy from the sun in the form of solar radiation for heat or to generate electricity. Solar powered electricity generation uses either photovoltaics or heat engines (concentrated solar power). A partial list of other solar applications includes space heating and cooling through solar architecture, daylighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Solar energy capture is also being linked to research involving water splitting and carbon dioxide reduction for the development of artificial photosynthesis or solar fuels. Pakistan is building solar power plants in Pakistani Kashmir, Punjab, Sindh and Balochistan. The program is under development by the International Renewable Energy Agency, China, and Pakistani private sector energy companies. Pakistan has also set a target to add 5% approximately 10,000 MW electricity through renewable energies by year 2030 besides replacement of 5% diesel with bio-diesel by year 2015 and 10% by 2025

Biomass

Biomass is biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material.

Biomass is matter usually thought of as garbage. Some of it is just stuff lying around -- dead trees, tree branches, yard clippings, left-over crops, wood chips and bark and sawdust from lumber mills. It can even include used tires and livestock manure.

Using biomass can help reduce global warming compared to a fossil fuel-powered plant. Plants use and store carbon dioxide (CO2) when they grow. CO2 stored in the plant is released when the plant material is burned or decays. By replanting the crops, the new plants can use the CO2 produced by the burned plants. So using biomass and replanting helps close the carbon dioxide cycle. However, if the crops are not replanted, then biomass can emit carbon dioxide that will contribute toward global warming.

So, the use of biomass can be environmentally friendly because the biomass is reduced, recycled and then reused. It is also a renewable resource because plants to make biomass can be grown over and over.

Today, new ways of using biomass are still being discovered. One way is to produce ethanol, a liquid alcohol fuel. Ethanol can be used in special types of cars that are made for using alcohol fuel instead of gasoline. The alcohol can also be combined with gasoline. This reduces our dependence on oil - a non-renewable fossil fuel. Statistics show that Pakistan possesses tremendous potential for generating renewable energy from biomass.The United Nations Industrial Development Organization (UNIDO) with funding from Global Environmental Facility (GEF) launched a US$1.82 million "Energy Project" with additional funding of US$5.30 million as co-finance from the Private sector in Ocotober 2013

The Project entitled: "Promoting Sustainable Energy Production and Use from Biomass in Pakistan" will promote market based adoption of modern biomass Gasification technologies in Pakistan for the next four years. The Project will be implemented in partnership with Centre for Energy Systems –National University of Science and Technology, Pakistan Poverty Alleviation Fund and Small and Medium Enterprise Development Agency, Private sector and Provincial Energy Departments.

Biofuel

Biofuel- is a wide range of fuels which are in some way derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Biofuels are gaining increased public and scientific attention, driven by factors such as oil price spikes and the need for increased energy security. Biofuel is a gas or liquid fuel made from plant material (biomass). Includes wood, wood waste, wood liquors, peat, railroad ties, wood sludge, spent sulfite liquors, agricultural waste, straw, tires, fish oils, tall oil, sludge waste, waste alcohol, municipal solid waste, landfill gases, other waste, and ethanol blended into motor gasoline Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe. Pakistan hopes to build anaerobic digesters in rural areas, for the production of Biogas to supplement gas yields. Pakistan State Oil on July 10, 2009 launched Pakistan's first environment-friendly fuel - E10 Gasoline - in Karachi, Lahore and Islamabad

Geothermal Energy

Hot water and steam from deep underground can be used to drive turbines: this is called geothermal energy. Several types of rock contain radioactive substances such as uranium. Radioactive decay of these substances releases heat energy, which warms up the rocks. In volcanic areas, the rocks may heat water so that it rises to the surface naturally as hot water and steam. Here the steam can be used to drive turbines and electricity generators.

Geothermal power station exists in places such as Iceland, California and Italy

In some places, the rocks are hot, but no hot water or steam rises to the surface. In this situation, deep wells can be drilled down to the hot rocks and cold water pumped down. The water runs through fractures in the rocks and is heated up. It returns to the surface as hot water and steam, where its energy can be used to drive turbines and electricity generators.

Advantages

Geothermal energy is a renewable energy resource and there are no fuel costs. No harmful polluting gases are produced.

Disadvantages

Most parts of the world do not have suitable areas where geothermal energy can be exploited.

Why is Renewable Energy Important for the Future of Our Society?

There are several important reasons that make renewable energy extremely important for the future of our society. Renewable energy still has a long way to go in order to replace fossil fuels and become primary source of energy consumption but things have been lately definitely moving in the right direction. But let us focus here about the future impact of renewable energy on our society.

Positive environmental impact is certainly one of the most important reasons. Fossil fuels when burn, create harmful greenhouse gas emissions and our planet is already feeling the impact of climate change. By using renewable energy instead of fossil fuels we would significantly decrease the current levels of greenhouse gas emissions, and this would have positive environmental impact for our entire planet.

Renewable energy is not all about environment as it can also give strong boost to our economy in form of new jobs. The number of people employed within the renewable energy industry is rapidly growing, giving many countries an excellent option to boost their economies in this post-recession period.

Renewable energy can improve our energy security by reducing the need for foreign oil import. The global oil market has been characterized by extremely volatile prices and our dependence on oil continues to grow. By switching to renewable energy and using more domestic

renewable energy sources instead of importing foreign oil we would drastically improve our energy security and energy independence, not to mention the fact that our money would stay inside our borders instead going to OPEC countries.

Renewable energy offers variety of different options to choose from. What this means is that countries can choose between sun, wind, biomass, geothermal energy, water resources, etc, depending on the potential of each of these sources.

Renewable energy technologies (*i.e.*, Solar, Wind, Bio, Hydro, Ocean and Hydrogen and Fuel) are clean sources of energy that have a much lower environmental impact than conventional energy technologies. For countries like Pakistan (rich in natural resources and with a population of over 180 millions), the importance of renewable energy becomes even more critical due to the fact of limited hydro potential and conflicting mindset of our feudal elite from the point of view of water resource management. Furthermore a growing disparity between energy demands and supply in Pakistan over a period of time, further poses threat to our long term survivability and existence as a just nation.

Only wind energy source in fact has capacity to collectively produce over 150,000 MW of electricity in Pakistan (even 140,000 MW is possible in Sindh) according to recent USAID report. Pre-requisite for producing and utilizing wind energy is the availability of necessary wind speed. An average acceptable wind speed in most parts of the world lies from 6.2 – 6.9 m/s (*fair category*) and 7.0 – 7.4 m/s (*good category*). Interestingly, wind speed in some parts of Pakistan (*e.g.*, Sindh corridor, Baluchistan and some northern areas) touches even excellent category of wind speed (*i.e.* more than 7.4 m/s). While the first 50 MW wind project is just inaugurated in Jhimpir, several such micro projects are needed to fully exploit the true potential of our wind energy generation capacity. Due to more favorable climatic conditions in Pakistan, solar PV possesses almost infinite potential on the other hand to generate electricity in Pakistan. Leveled cost of electricity generation from different sources of energy as of today (*From "US Department of Energy Estimates 2012" published in annual Energy Outlook*) are 9.96 for conventional coal, 6.87 for natural gas, 11.2 for nuclear, 9.96 for geothermal, 9.0 for biomass, 9.6 for onshore wind, 15.6 for solar PV, and 8.9 for hydro in Cents/kWh. The experts forecast a large expansion of the amount of installed solar power, increasing more than 10 times over the decade from 2010 to 2020, an expansion that will continue at a similar rate until 2025. Fortunately, there is a lot of availability of empty land in the country side in Pakistan where such initiatives are potentially, economically and technologically feasible.

Difference *between* Renewable *and* Non-renewable Resources (CSS 2013)

Renewable Resources	Non-renewable Resources
Renewable resources are those which can be used again and again	Non-renewable resources are those which are used only for a limited time and rate.
Renewable resources have a higher rate of decomposition than their rate of consumption	Non-renewable resources have a lower rate of decomposition than the rate of consumption
There are five main types of renewable resources that we use for energy. Wind is harnessed from Earth's natural weather patterns. Hydropower generally comes from flowing rivers and from reservoirs. Solar	Non-renewable energy generally refers to energy collected from fossil fuels. Fossil fuels are fuels derived from the decomposition of dead organisms (fossils), some of which are hundreds of millions of

energy comes from the Sun's light and radiation. Biomass comes from burning plants, plant waste or fuel made from plants. Geothermal energy is collected from the heat produced by the Earth underneath the ground.	years old. Examples of fossil fuels include coal, crude petroleum and natural gas. These fuels are not self-sustaining at a rate close to human use.
Renewable sources have low carbon emissions, therefore they are considered as green and environment friendly.	Non-renewable sources release toxic gases in the air when burnt which are the major cause for global warming.

Q: Why Nuclear Energy is being preferred in Developed Countries?

(CSS 2013)

The continued growth of world's population and gradual increase of people's living standards in developing countries have sped up the exhaustion of fossil fuels and caused large amount of greenhouse gas emissions. Although renewable energy sources (e.g. wind energy, solar energy, hydro energy and biomass energy) have developed rapidly in recent years, limitations existing in these energy sources (e.g. non-continuous electricity supply of wind and solar power generation, resource constraints for hydro power and biomass energy etc.) still set barriers to launching application in large scale and fulfilling world's energy demand in near future. Currently, great attention has been paid to nuclear technology

Like any other energy source and technology, nuclear energy has advantages and drawbacks in each of the three dimensions of sustainable development: environmental, social and economic.

Several factors now favor nuclear energy, in both the developed and the developing world. One is that whatever their attraction, renewable energy sources, such as biogas or even solar, are unlikely to meet the energy demands of the world's rapidly growing urban population.

According to one estimate, the number of people living in cities may double to almost 7.5 billion between now and 2050, while the rural population could fall from 3 to 2.5 billion. Alternative, renewable fuels are unlikely to be able to cope with the strain this will put on centralized energy systems.

The second major factor is the need to tackle climate change. The only realistic chance of slowing global warming is to drastically reduce carbon emissions. As the nuclear industry has been pointing out for several years, nuclear energy is an obvious way to do this.

In the long-term, the world needs to turn towards low-energy economies based on renewable energy such as wind, biomass and solar energy, and perhaps with the addition of fusion energy, if that can be made safe and economic. But too rapid a transition could bring energy shortages that disrupt industry and have a devastating social impact.

This prediction is behind the UK government's new energy policy paper, published last week. The paper concludes that expanding nuclear energy is an essential component of any strategy capable of combating global warming while continuing to meet the country's energy needs.

A third factor is the evolution of nuclear technology itself. No one is claiming that nuclear power is 100 per cent safe. But new technological advances and new reactor designs have both reduced the likelihood of accidents and bolstered our ability to deal with any that do occur.

Today nuclear energy provides nearly one quarter of the electricity consumed in OECD countries and is a daily fact of life in several of them. This has enabled it to become a proven, mature technology benefiting from broad industrial experience–more than 12,000 reactor-years of operation accumulated mainly in OECD countries. State-of-the-art nuclear energy systems in operation worldwide have demonstrated highly satisfactory technical and economic performance. Moreover, extensive R&D programmes under way in many countries, often as part of international endeavours, aim to make even more progress to enhance safety and proliferation resistance, to reduce uranium consumption and waste and to increase the competitiveness of nuclear energy.

In short, all nuclear energy indicators of safety, reliability, competitiveness and efficient use of natural resources, as well as health and environmental protection, show a continuous trend of improvement. Clearly, nuclear could make a major contribution to diversification, security of energy supply and the reduction of greenhouse gas emissions in a cost-effective way. Nuclear energy development can become a key part of sustainable energy mixes provided governments, industry and civil society work together to lay out a robust policymaking framework for all options to be assessed and developed according to their respective costs and benefits for society. That includes cooperating multilaterally to ensure the technology does indeed develop to the highest standards possible in the fields of safety and reliability, health and environmental protection, proliferation resistance and physical protection, and economics.

What is Alternative Energy?

Is alternative energy the same as renewable energy? In order to define alternative energy we first need to define alternative energy sources. Alternative energy source is any source of energy that does not belong to traditional energy sources. Traditional energy sources are fossil fuels (coal, oil and natural gas). Some dictionaries, like for instance, Oxford dictionary puts alternative energy sources in correlation to environment by stating that term „alternative energy sources" refers to energy sources that do not use up natural resources or harm the environment.

There have been many opposite opinions about what this term should and shouldn't include, and even today defining alternative energy sources will often be looked at from several different perspectives. For instance nuclear energy is thought by some to be alternative source of energy while other say that only renewable energy sources are in fact alternative energy sources. The same situation is with hydropower because some think that hydropower is a traditional source of energy together with fossil fuels while others do not look at hydropower as traditional source of energy.

To stay out of these controversies as much as possible let us focus here on the most common alternative energy sources: solar energy, wind energy and geothermal energy. Other alternative energy sources include the likes of biofuels, tidal and wave power, and hydrogen.

Solar energy is coming from the Sun and this is the most abundant source of energy available on our planet. Solar power technologies have recently experienced huge decline in prices but nonetheless solar industry still heavily depends on subsidies and other tax incentives. Solar energy industry also needs to find the adequate energy storage solution in order to solve the intermittency issue (since the sun doesn't shine all day long). Given the enormous potential of solar energy as well as large funds and numerous researches it is pretty realistic to say that one day solar energy will become the dominant energy source in the world (once it reaches cost parity with fossil fuels).

Wind energy is better in cost-competitiveness when compared to solar energy but still suffers from intermittency issue just like this is the case with solar. Many countries have started massive wind energy expansion (most notably China). In years to come it is expected that the global wind energy industry will focus offshore, in areas with more powerful and more frequent ocean winds.

Geothermal energy refers to the heat stored within the earth's core. Geothermal energy is unlike solar and wind available 24-7 but has high drilling and exploration costs, which means that with current technological development harnessing geothermal energy is only viable in areas near tectonic plates. This is also the reason why there are only 24 countries in the world currently harnessing geothermal energy.

These three alternative energy sources have one big advantage over traditional fossil fuels, and that is their environmentally friendly character. Fossil fuel burning still remains the main contributor to climate change and air pollution which means that world needs to replace fossil fuels with alternative energy sources as soon as possible in order to avoid environmental disaster of gigantic proportions.

Energy Conservation

Importance *from environmental and economic point of View*

Term energy conservation refers to different methods and processes that have the main purpose in reducing the total amount of energy that is currently being used by industry, households and various other sectors of our society.

Energy conservation is important from many different perspectives and not just because saving energy means saving our money by lowering our monthly energy bills (the economic importance of energy conservation). Energy conservation methods are also extremely important from the environmental point of view because we are still heavily dependent on fossil fuels, and by reducing our energy needs we are also reducing the global level of greenhouse gas emissions that contribute to climate change and global warming.

Energy conservation will no doubt play even bigger role in years to come. We are still heavily dependent on fossil fuels and the energy consumption continues to grow heavily in all parts of the world, particularly with the rise of new economic giants from Asia, namely China and India.

The currently dominant fossil fuels are finite energy resources that will eventually become depleted and in this sense energy conservation is of vital importance to ensure reliability of future energy delivery, at least until the time when renewable energy industry will mature enough to replace fossil fuel fired power plants.

The ever-increasing demand for more and more energy is in most cases satisfied with the increased energy production and countries often tend to forget about energy conservation methods as a more logical solution to satisfy increased energy demand.

Energy conservation is at this point much better solution than increased energy production, especially because increased energy production means even more fossil fuels, and even bigger dependence on foreign fuel import. The continuous dependence on foreign fuel import deteriorates our future energy security and makes us vulnerable to volatile oil prices.

Efficient Energy Use

Energy conservation refers to reducing energy through using less of an energy service. Energy conservation differs from efficient energy use, which refers to using less energy for a constant service. For example, driving less is an example of energy conservation. Driving the same amount with a higher mileage vehicle is an example of energy efficiency. Energy conservation and efficiency are both energy reduction techniques.

Even though energy conservation reduces energy services, it can result in increased

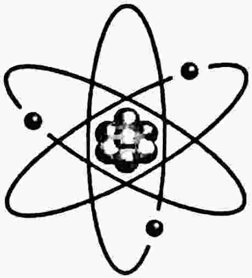
financial capital, environmental quality, national security, and personal financial security. It is at the top of the sustainable energy hierarchy

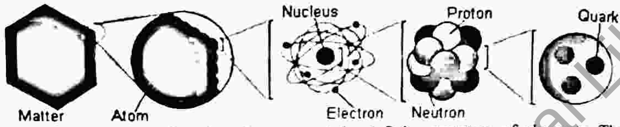
Less consumption of energy by improving efficiency, avoiding wastages without sacrificing comfort or standard of living is in the interest of everybody - individuals, each family, business and industry and Pakistan as a nation. This can be achieved with good habits, attitude and behaviour of every individual.

Some of the simple good habits of energy saving are

- Use of energy saving lighting at home, commercial building and public places.
- Switching off lights, fans, air-conditioners etc. in unoccupied areas.
- Use of energy efficient cars and other vehicles.
- Good driving habits like driving at optimum speed to obtain the best fuel efficiency, avoiding use of braking too often by speed control.
- Switching off electronic equipment like TV, computers, DVD/VCD players, music system when not in use without keeping them on stand by mode.
- Use of public transport and walking to the maximum extent possible

Involvement of everybody- children, youth and adults- is essential in energy conservation and this is possible by educating them appropriately and modifying their behaviour.





Atoms are the basic units of matter and the defining structure of elements. The term "atom" comes from the Greek word for indivisible, because it was once thought that atoms were the smallest things in the universe and could not be divided. We now know that atoms are made up of three particles: protons, neutrons and electrons — which are composed of even smaller particles such as quarks.

Atomic particles

Protons and neutrons are heavier than electrons and reside in the nucleus at the center of the atom. Electrons are extremely lightweight and exist in a cloud orbiting the nucleus. The electron cloud has a radius 10,000 times greater than the nucleus.

Protons and neutrons have approximately the same mass. However, one proton weighs more than 1,800 electrons. Atoms always have an equal number of protons and electrons, and the number of protons and neutrons is usually the same as well. Adding a proton to an atom makes a new element, while adding a neutron makes an isotope, or heavier version, of that atom.

Nucleus

The nucleus was discovered in 1911 by Ernest Rutherford, a physicist from New Zealand, who in 1920 proposed the name proton for the positively charged particles of the atom. Rutherford also theorized that there was also a neutral particle within the nucleus, which James Chadwick, a British physicist and student of Rutherford, was able to confirm in 1932.

Virtually all the mass of the atom resides in the nucleus. The protons and neutrons that make up the nucleus are approximately the same mass (the proton is slightly less) and have the same angular momentum, according to Lawrence Berkeley National Laboratory.

The nucleus is held together by the "strong force," one of the four basic forces in nature. This force between the protons and neutrons overcomes the repulsive electrical force that would, according to the rules of electricity, push the protons apart otherwise. Some atomic nuclei are unstable because the binding force varies for different atoms based on the size of the nucleus. These atoms will then decay into other elements, such as carbon-14 decaying into nitrogen-14.

Protons

Protons are positively charged particles found within atomic nuclei. Rutherford discovered them in experiments with cathode-ray tubes conducted between 1911 and 1919. Protons are slightly smaller in mass than neutrons with a relative mass of 0.9986 (as compared with the mass of the neutron being 1) or about 1.673×10^{-27} kg.

The number of protons in an atom defines what element it is. For example, carbon atoms have six protons, hydrogen atoms have one and oxygen atoms have eight. The number of protons in an atom is referred to as the atomic number of that element. The number of protons in an atom also determines the chemical behavior of the element. The Periodic Table of the Elements arranges elements in order of increasing atomic number.

Three quarks make up each proton — two "up" quarks (each with a 2/3 positive charge) and one "down" quark (with a 1/3 negative charge) — and they are held together by other subatomic particles called gluons, which are massless.

Electrons

Electrons are tiny compared to protons and neutrons, over 1,800 times smaller than either a proton or a neutron. Electrons have a relative mass of 0.0005439 (as compared with the mass of a neutron being 1) or about 9.109×10^{-31} kg.

J.J. Thomson, a British physicist, discovered the electron in 1897. Originally known as "corpuscles," electrons have a negative charge and are electrically attracted to the positively charged protons. Electrons surround the atomic nucleus in pathways called orbitals, an idea that was put forth by Erwin Schrödinger, an Austrian physicist, in the 1920s. Today, this model is known as the quantum model or the electron cloud model. The inner orbitals surrounding the atom are spherical but the outer orbitals are much more complicated.

An atom's electron configuration is the orbital description of the locations of the electrons in a typical atom. Using the electron configuration and principles of physics, chemists can predict an atom's properties, such as stability, boiling point and conductivity.

Typically, only the outermost electron shells matter in chemistry. The inner electron shell notation is often truncated by replacing the longhand orbital description with the symbol for a noble gas in brackets. This method of notation vastly simplifies the description for large molecules.

For example, the electron configuration for beryllium (Be) is $1s^2 2s^2$, but it's is written $[He]2s^2$. [He] is equivalent to all the electron orbitals in a helium atom. The letters, s, p, d, and f designate the shape of the orbitals and the superscript gives the number of electrons in that orbital. Uranium, as another example, has an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4e^{14} 5d^{10} 6p^6 7s^2 5f^4$, which can be simplified to $[RN]7s^2 5f^4$.

Neutrons

The neutron is used as a comparison to find the relative mass of protons and electrons (so it has a relative mass of 1) and has a physical mass of 1.6749×10^{-27} kg.

The neutron's existence was theorized by Rutherford in 1920 and discovered by Chadwick in 1932. Neutrons were found during experiments when atoms were shot at a thin sheet particles with no charge were released -- the neutron.

of beryllium. Subatomic particles found within all atomic nuclei (except for hydrogen-1).

Neutrons are uncharged particles found within all atomic nuclei (except for hydrogen-1). Like protons, neutrons are also made of

A neutron's mass is slightly larger than that of a proton. Like protons, neutrons are also made of quarks — one "up" quark (with a positive 2/3 charge) and two "down" quarks (each with a negative 1/3 charge).

Atomic Models

Our ideas about the nature of atoms have progressed over the last two centuries (and continue to develop today).

John Dalton introduced a new form of the ancient Greek idea of atoms at the beginning of the nineteenth century.

In 1897, J.J. Thomson discovered the electron and suggested the 'plum pudding' model of the atom.

In 1911, Rutherford suggested that electrons orbit the atomic nucleus like planets round the Sun.

In 1914, Bohr modified Rutherford's model by introducing the idea of energy levels.

The atom as a positively charged nucleus with negatively charged electrons orbiting the nucleus in energy levels (or shells).

Ions

Sometimes atoms gain or lose electrons. The atom then loses or gains a "negative" charge. These atoms are then called ions.

- **Positive Ion** - Occurs when an atom ***loses an electron*** (negative charge) it has more protons than electrons.
- **Negative Ion** - Occurs when an atom ***gains an electron*** (negative charge) it will have more electrons than protons.

Charged atomic particles are called ions.

Quarks

Quarks and Leptons are the building blocks which build up matter, i.e., they are seen as the "elementary particles". In the present standard model, there are six "flavors" of quarks. They can successfully account for all known mesons and baryons (over 200). The most familiar baryons are the proton and neutron, which are each constructed from up and down quarks. Quarks are observed to occur only in combinations of two quarks (mesons), three quarks (baryons). There was a recent claim of observation of particles with five quarks (pentaquark), but further experimentation has not borne it out.

The name "quark" was taken by Murray Gell-Mann from the book "Finnegan's Wake" by James Joyce. The line "Three quarks for Muster Mark..." appears in the fanciful book. Gell-Mann received the 1969 Nobel Prize for his work in classifying elementary particles.

The up and down quarks are the most common and least massive quarks, being the constituents of protons and neutrons and thus of most ordinary matter.

Atomic Number *and* Mass Number

The atomic number of an atom is the number of protons it contains. All the atoms of a particular element have the same atomic number (number of protons). The atoms of different elements have different numbers of protons. For example, all oxygen atoms have 8 protons and all sodium atoms have 11 protons.

The mass number of an atom is the total number of protons and neutrons it contains. The mass number of an atom is never smaller than the atomic number. It can be the same, but is usually bigger.

Isotopes

The number of neutrons in a nucleus determines the isotope of that element. For example, hydrogen has three known isotopes: protium, deuterium and tritium. Protium, symbolized as ^1H, is just ordinary hydrogen; it has one proton and one electron and no neutrons. Deuterium (D or ^2H) has one proton, one electron and one neutron. Tritium (T or ^3H) has one proton, one electron and two neutrons.

Heavy Water

(CSS 1989, 1985, 2013)

Heavy water is deuterium monoxide or water in which one or more of the hydrogen atoms is a deuterium atom. Deterium monoxide has the symbol D_2O or ^2H_2O. It is sometimes referred to simply as deuterium oxide. In comparison, in ordinary water, which is the "ordinary water" used for a deuterium standard on Earth, there are only about 156 deuterium atoms per million hydrogen atoms.

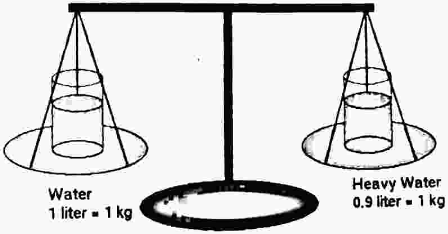
Heavy water was first produced in 1932, a few months after the discovery of deuterium the stable heavy isotope of hydrogen.

Some Physical Properties of Heavy Water

- Heavy water is colourless, tasteless and odourless liquid.
- It has all higher values for physical constants than the corresponding values of ordinary water.

It's well known that physical-chemical properties of heavy water are totally different from properties of usual water: boiling temperature of heavy water is **+101,4°C**, the freezing point equals to **+3,81°C** and it has **10%** higher density.

An oxygen atom is about 16 times heavier than a hydrogen atom. So a water molecule is about 16+1+1=18 times heavier than a hydrogen atom, and a heavy water molecule is 16+2+2=20 times heavier than a hydrogen atom. In other words, heavy water is 20/18=1.11 times heavier than ordinary water.



Heavy water may contain as much as 100% D2O, and usually the term refers to water that is highly enriched in deuterium. The isotopic substitution with deuterium alters the bond energy of the hydrogen-oxygen bond in water, altering the physical, chemical, and especially biological properties of the pure or highly-enriched substance to a larger degree than is found in most isotope-substituted chemical compounds.

Needs to note, that heavy water is probably fully Earth born product – in outer space it was not registered. Deuterium is formed from protium after it captured neutron from cosmic radiation. World Ocean, polar and mountain ice, atmospheric moisture is the main natural "factories" of deuterium production.

Need to remember that heavy water is indistinguishable from normal, but its consumption inside the organism can cause severe poisoning. Not surprisingly, local people in high-latitude regions do not use river ice for cooking - only lake ice or snow.

Biological *and* Physiological effects

Heavy water of high concentration retards the growth of plants and animals. For example, tobacco seeds do not grow in heavy water. Pure heavy water kills small fishes, tadpoles and mice when fed. Heavy water has germicide and bactericide properties too. Water containing small quantity of D_2O acts as a tonic and stimulates vegetable growth. Certain moulds have been found to develop better in heavy water in comparison to ordinary

Uses *of* Heavy Water

The following are the important uses of heavy water:

As a neutron moderator

Fission in uranium-235 is brought by slow speed neutron. Heavy water is used for this purpose in nuclear reactors as moderators.

For the preparation of deuterium

Heavy water produces deuterium on electrylosis or by its decomposition with metals.

As a tracer compound

Heavy water is used as a tracer compound for studying various reaction mechanisms. It has also been used for studying the structure of some oxyacids of phosphorus such as H_3PO_2 and H_3PO_4, to determine the number of ionizable hydrogen atoms.

Pure Water

Pure water is a clear, colorless, and odorless liquid that is made up of one oxygen and two hydrogen atoms. The chemical formula of the water molecule, H_20, was defined in 1860 by the Italian scientist Stanislao Cannizzarro. Water is a very powerful substance that acts as a medium for many reactions, which is why it is often referred to as the "universal solvent." Although pure water is a poor conductor of electricity, impurities that occur naturally in water transform it into a relatively good conductor. Water has unusually high boiling (100° C/212° F) and freezing (0° C/32° F) points. It also shows unusual volume changes with temperature. As water cools, it contracts to a maximum density of 1 grain per cubic centimeter at 4° C (39° F). Further cooling actually causes it to expand, especially when it reaches the freezing point. The fact that water is denser in the liquid form than the solid form explains why an ice cube floats in a beverage, or why a body of water freezes from the top down. While the density property of water is of little importance to the beverage example, it has a tremendous impact on the survival of aquatic life inhabiting a body of water.

Periodic Table

The periodic table is a tabular arrangement of the chemical elements by increasing atomic number which displays the elements so that one may see trends in their properties.

The periodic table of elements arranges all of the known chemical elements in an informative array. Elements are arranged from left to right and top to bottom in order of increasing atomic number. Order generally coincides with increasing atomic mass.

The rows are called periods. The period number of an element signifies the highest energy level an electron in that element occupies (in the unexcited state), according to the Los Alamos National Laboratory. The number of electrons in a period increases as one moves down the periodic table; therefore, as the energy level of the atom increases, the number of energy sub-levels per energy level increases.

Elements that occupy the same column on the periodic table (called a "group") have identical valance electron configurations and consequently behave in a similar fashion chemically. For instance, all the group 18 elements are inert gases.

Period \ Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	36 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cc	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Chemical Bonding

Chemical compounds are formed by the joining of two or more atoms. A stable compound occurs when the total energy of the combination has lower energy than the separated atoms. The bound state implies a net attractive force between the atoms ... a chemical bond. The two extreme cases of chemical bonds are:

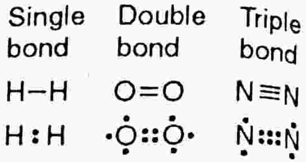
- **Covalent bond:** bond in which one or more pairs of electrons are shared by two atoms.
- **Ionic bond**: bond in which one or more electrons from one atom are removed and attached to another atom, resulting in positive and negative ions which attract each other.

Other types of bonds include metallic bonds and hydrogen bonding.

Covalent Bond

Covalent bond-- a bond is form between atoms with electrons are shared by the nuclei.

If the bonded atoms are non-metals and identical (as in N2 or O2), the electrons are shared equally between the two atoms, and the bond is called non-polar covalent. If the atoms are non-metals but differ (as in nitric oxide, NO), the electrons are shared unequally and the bond is called polar covalent -polar because the molecule has a positive and a negative electric pole much like the north and south poles of a magnet and covalent because the atoms share electrons between them, even though unequally. These substances are not electrical conductors, nor do they have luster, ductility, or malleability



- A single bond involves two atoms sharing one electron pair
- A double bond involves two atoms sharing two pairs of electrons
- A triple bond involves two atoms sharing three electron pairs

Examples of Covalent Bond

Hydrogen Chloride

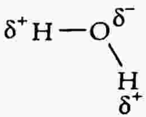
$H + Cl = HCl$

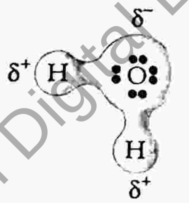
$O = C = O = CO_2$

$H - O - H = H_2O$

Polar Covalent Bonds

Covalent bonds, in which the sharing of the electron pair is unequal, with the electrons spending more time around the more nonmetallic atom, are called polar covalent bonds. In such a bond there is a charge separation with one atom being slightly more positive and the other more negative, i.e., the bond will produce a dipole moment. The ability of an atom to attract electrons in the presense of another atom is a measurable property called electronegativity.





Ionic Bond

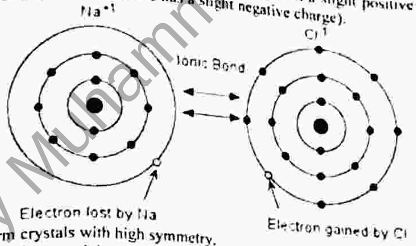
When atoms become charged ions the force of attraction between oppositely charged ions results in an ionic bond.

For example

Na has one electron in its outermost shell. It will tend to give up this electron to become Na^{+1} ion. Similarly, Cl has 7 electrons in its outermost shell and would like to gain an electron to become Cl^{-1} ion. Once these atoms become Na+1 and Cl-1, the force of attraction between the oppositely charged ions results in an ionic bond

Ionic bonds are non-directional in nature, that is the attractive forces occur form all directions. Crystals made of ionically bonded atoms tend to have the following properties

- Dissolve easily in polar solvents like water (H_2O is a polar solvent because the hydrogen ions occur on one side the water molecule and give it a slight positive charge while the other side of the water molecule has a slight negative charge).



- Tend to form crystals with high symmetry.
- Moderate hardness and density.
- High melting temperatures.
- Generally poor conductors of heat and electricity (they are good materials for thermal and electrical insulation).

Covalent Bonds *vs* Ionic Bonds

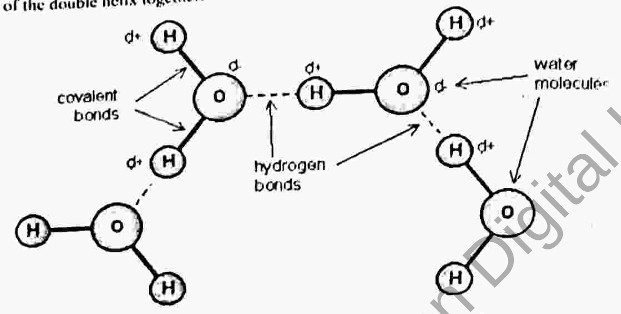
	Covalent Bonds	Ionic Bonds
Polarity	Low	High
Formation	A covalent bond is formed between two non-metals that have similar electronegativities. Neither atom is "strong" enough to attract electrons from the other. For stabilization, they share their electrons from outer molecular orbit with others	An ionic bond is formed between a metal and a non-metal. Non-metals (-ve ion) are "stronger" than the metal (+ve ion) and can get electrons very easily from the metal. These two opposite ions attract each other- and form the ionic bond.
Shape:	Definite shape	No definite shape
Melting point	low	High
	Covalent bonding is a form of chemical bonding between two non metallic atoms which is characterized by the sharing of pairs of electrons between atoms and other covalent bonds	Ionic bond, also known as electrovalent bond is a type of bond formed from the electrostatic attraction between oppositely charged ions in a chemical compound. These kinds of bonds occur mainly between a metallic and a non metallic atom
Boiling point:	Low	High
Examples	Methane (CH4), Hydro Chloric acid (HCl)	Sodium chloride (NaCl), Sulphuric Acid (H2SO4)
Occurs between	Two non-metals	One metal and one non-metal

Hydrogen Bonding

Hydrogen bonding differs from other uses of the word "bond" since it is a force of attraction between a hydrogen atom in one molecule and a small atom of high electronegativity in another molecule. That is, it is an intermolecular force, not an intramolecular force as in the common use of the word bond

When hydrogen atoms are joined in a polar covalent bondwith a small atom of high electronegativity such as O, F or N, the partial positive charge on the hydrogen is highly concentrated because of its small size. If the hydrogen is close to another oxygen, fluorine or nitrogen in another molecule, then there is a force of attraction termed a dipole-dipole interaction. This attraction or "hydrogen bond" can have about 5% to 10% of the strength of a covalent bond. Hydrogen bonding has a very important effect on the properties of water and ice.

Hydrogen bonding is also very important in proteins and nucleic acids and therefore in life processes. The "unzipping" of DNA is a breaking of hydrogen bonds which help hold the two strands of the double helix together.



Metallic Bonds

The properties of metals suggest that their atoms possess strong bonds, yet the ease of conduction of heat and electricity suggest that electrons can move freely in all directions in a metal. The general observations give rise to a picture of "positive ions in a sea of electrons" to describe metallic bonding.

Hard Water and Soft Water

Hard Water (CSS 2011)

"Water that produces curd with soap and produces very little lather is called hard water. Hard water affects cleaning ability of soap."

Hard water contains bicarbonate, chlorides and sulphates (*any one or all*) of calcium and , magnesium

Soft Water

"Water that produces lather with soap easily is called soft water. Soft water does not affect cleaning action of soap"

Types of Hard Water

There are two types of hard water.

1. Temporary hard water
2. Permanent hard water

Temporary Hard Water

"Water that contains bicarbonate of calcium and magnesium or of both is called temporary hard water."

These bicarbonate are soluble in water and produce corresponding ions.

$$Mg(HCO_3)_2 \rightarrow Mg^{+2} + 2HCO_3^{-1}$$

$$Ca(HCO_3)_2 \rightarrow Ca^{+2} + 2HCO_3$$

Permanent Hard Water

Water that contains chlorides or sulphates of calcium or magnesium or of both is called permanent water.

$$CaCl_2 \rightarrow Ca^{+2} + 2Cl^{-1}$$

$$MgSO_4 \rightarrow Mg^{+2} + SO_4^{-2}$$

These compounds are soluble in water and produce corresponding ions.

Removal of Hardness Water

"Softening" is the term which refers to the process of hardness removal. We can boil water to remove temporary hardness

Chemical Process of Boiling Hard Water

Temporary hardness in water can be easily removed by boiling. On boiling, calcium/magnesium bicarbonate decomposes to give calcium/magnesium carbonate, which is insoluble in water. Therefore, it precipitates out

$$Ca(HCO_3)_2 \xrightarrow{\text{boiling}} \underset{\text{insoluble calcium carbonate}}{CaCO_3\downarrow} + H_2O + CO_2$$

Adding Slaked Lime *(Clark's Process)*

In Clark's process, slaked lime, $Ca(OH)_2$ is added to temporary hard water. Insoluble calcium carbonate precipitate out and no longer produce hardness

$$Ca(HCO_3)_2 + \underset{\text{slaked lime}}{Ca(OH)_2} \longrightarrow \underset{\text{insoluble calcium carbonate}}{2CaCO_3} + 2H_2O$$

Adding Washing Soda

Calcium and magnesium ions present in hard water react with sodium carbonate to produce insoluble carbonates. The water now contains soluble and harmless sodium salts.

$$\underset{\text{cause of permanent hardness}}{CaSO_4} + Na_2CO_3 \longrightarrow \underset{\text{insoluble}}{CaCO_3\downarrow} + Na_2SO_4$$

$$\underset{\text{cause of permanent hardness}}{MgCl_2} + Na_2CO_3 \longrightarrow \underset{\text{insoluble}}{MgCO_3} + 2NaCl$$

Ion Exchange Process *(Permutit Process)*

Permutit or sodium aluminium silicate is a complex chemical compound, which occurs as a natural mineral called Zeolite. Permutit or zeolites are insoluble in water and have the property of exchanging ions present in them with the ions present in the solution. Permutit or zeolites are packed in a suitable container and a slow stream of hard water is passed through this material. As a result, calcium and magnesium ions present in hard water are exchanged with sodium ions in the permutit (Na'Al-Silicate). The outgoing water contains sodium salts, which do not cause hardness.

$$\underset{\text{in hard water}}{CaCl_2} + \underset{\text{permutit}}{2Na^+(Al\text{-}Silicate^-)} \longrightarrow Ca(Al\text{-}Silicate)_2 + 2NaCl$$

$$\underset{\text{in hard water}}{MgSO_4} + \underset{\text{permutit}}{2Na^+(Al\text{-}Silicate^-)} \longrightarrow Mg(Al\text{-}Silicate)_2 + Na_2SO_4$$

This is the basic concept of ion exchange and hardness removal.

Disadvantage of Hard Water

Domestic:

- Hard water affects cleaning ability of soap.
- When hard water is used for washing, large amount of soap is consumed.

Industrial:

- Hard water can cause "Scaling" inside the pipes that transport water. Therefore if we use hard water in turbines and heat exchangers, their pipes will be corroded

Health:

- Hard water when used for drinking for long period can lead to stomach disorders. Especially hard water contains magnesium sulphate can weaken the stomach permanently.

Difference *between* HARD Water *and* HEAVY Water

Heavy Water:

The formula of ordinary water is H2O. It contains hydrogen. Deuterium 21H (D) is a heavy isotope of hydrogen. It has one neutron and one proton in its nucleus, Deuterium oxide D20 Is heavy water which is used as a moderator in nuclear reactors for slowing down high speed neutrons. Neutrons are slowed down by striking with the nuclei of heavy water molecules.

Hard Water:

Hard water fails to form lather with soap while soft water quickly forms lather with soap. Hardness of water is mainly due to salts of calcium, particularly the soluble bicarbonates formed by the action of rain water and carbon dioxide from air on limestone. This is called temporary hardness. Sulfates and chlorides of calcium and magnesium cause permanent hardness.

Radioactivity

(CSS 2013 Fsd Re-exam)

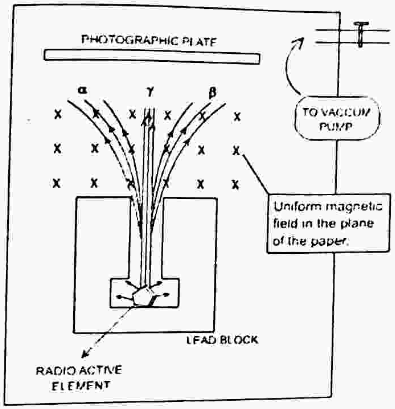
The discovery of the phenomenon of radioactivity was purely accidental. In 1896, Henry Becquerel, a French scientist accidentally found that in presence of salt of uranium, photographic plates got heavily fogged even though they were wrapped in opaque paper. He concluded that the uranium salt must be giving off penetrating radiations similar to X-rays discovered one year earlier. Two years later, Madam Curie named the phenomenon radioactivity.

The phenomenon of spontaneous disintegration of an unstable nucleus of naturally occurring isotope accompanied by emission of active radiations line a, b and g radiations is known as Natural Radioactivity.

These radiations come from the breakup of the central core or nuclei of heavier elements like thorium, uranium etc. Elements with atomic number above 83 have very heavy and unstable nuclei. Being unstable, these nuclei spontaneously break up to form stable elements with lower atomic numbers. In the process of this breakup, the three types of radiations are given out.

Experiment

Experiments by Becquerel, Rutherford and Marie Sklodowska Curie and her husband Pierre Curie had shown that uranium, radium and certain other radioactive substances gave off three types of radiations. They performed many experiments to discover the properties of these radiations.



Deflection of a, b and g rays

- The radioactive material was kept in a small cavity in a block of lead.
- The whole apparatus was enclosed in an evacuated vessel as shown here.
- An electric field was applied.

- It was observed that the beam is split up into three components.
- The radiations, which emerged from the radioactive material, were made to strike a photographic plate. These radiations produced three different spots on the photographic plate.

Conclusions

- The rays that deflected towards the negative plate consist of positively charged particles and these were called alpha rays.
- The rays, which deflected towards the positive plate, consist of negatively charged particles and these rays were known as the beta rays.
- The rays, which did not deflect, do not contain any charged particles and described these rays as gamma rays.

General Characteristics of Natural Radioactivity

- It is a nuclear phenomenon.
- It is due to the instability of the nucleus.
- It is a spontaneous, continuous and irreversible process.
- It is independent of external factors such as pressure, temperature, state of substance, electrical field, magnetic field, catalyst etc.
- A radioactive element emits α β and γ radiations.
- Due to the emission of an α particle, atomic number decreases by 2 units and mass number decreases by 4 units.
- Due to the emission of β particle, atomic number increases by 1 unit but the mass number remains the same.
- A radioactive element does not emit α and β particles simultaneously.
- The original radioactive nucleus or element is called a parent element and the new element formed is known as daughter element.
- The physical and chemical properties of daughter element are different than that of the parent element.

Characteristics of Alpha Rays (CSS 2013 Fsd Re-Exam)

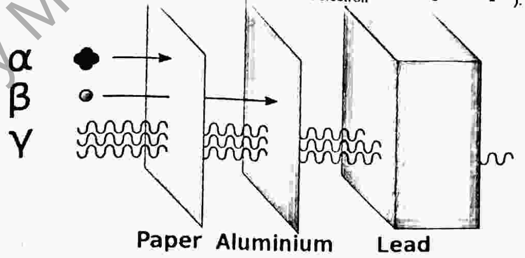
Alpha rays consist of stream of positively charged particles carrying charge of +2 units and a mass of four units on the atomic weight scale (i.e., 4 amu). They consist of 2 protons and 2 neutrons. In other words, these particles are helium nuclei and therefore indicated as $_2He^4$.

- They affect photographic plate
- They are deflected only slightly towards the negative plate in electric field. They are also deflected by magnetic field.
- These particles can ionize gases. Alpha rays have maximum ionizing power.
- They have a velocity of the order of 1×10^7 m s^{-1}.
- They have very little penetrating power.
- By emission of an α - particle, atomic number of nucleus decreases by 2 units and mass number by 4 units

Characteristics of Beta Rays (CSS 2013 Fsd Re-Exam)

- Beta rays are made up of streams of negatively charged particles similar to electrons. Thus, beta particle has a unit negative charge and a negligible mass. They are electrons.
- They affect photographic plate.
- They get deflected to the maximum extent towards the positive plate in electric field. They are also deflected by magnetic field.

- Their ionising power is less than that of α - rays. (It is about one hundredth of α - particles.
- Their velocity varies with the source and is almost equal to the velocity of light, about 2.7 x 10^8 m/s.
- Their penetration power is about 100 times more than that of α - particles.
- By emission of a b - particle, atomic number of nucleus increases by one whereas mass number remains same. (this is because, the ejection of a b - particle results from the transformation of a neutron into a proton and an electron $^{0}_{1}n \rightarrow ^{1}_{1}P + ^{0}_{-1}e$).



Characteristics of Gamma (g) Rays (CSS 2013 Fsd Re-Exam)

- They are electromagnetic radiations like X-rays having very short wavelength, in the range of 10^{-10} m to 10^{-13} m.
- They affect photographic plate.
- They are unaffected by electric and magnetic fields.
- Their ionizing power is low, (about one hundredth of b - particles).
- Their velocity is same as that of light.
- Their penetrating power is very high, about 100 times more than that of b - particles. Hence, they are also known as hard rays.
- When a and b particles are emitted by an atom, there is always a rearrangement in the nucleus and during this process some energy is given out in the form of g - rays. Thus, emission of gamma rays accompanies virtually all nuclear reactions. There is no change in the mass number or atomic number of the nucleus as g - rays have negligible mass.

The Three Types of Radioactivity

Alpha particles

- Alpha particles are made of **2 protons and 2 neutrons.**
- This means that they have a **charge** of **+2**, and a **mass** of **4**
- *(The mass is measured in "atomic mass units", where each proton & neutron=1)*
- We can write them as $^{4}_{2}\alpha$, or, because they're the same as a helium nucleus, $^{4}_{2}$HeAlpha particles are relatively **slow** and **heavy**.
- They have a **low penetrating power** - you can stop them with just a sheet of **paper**.

- Because they have a large charge, alpha particles ionise other atoms strongly.

Beta particles

- Beta particles have a charge of **minus 1**, and a mass of about **1/2000th of a proton**. This means that beta particles are **the same as an electron**. We can write them as β^- or, because they're the same as an electron, e^-.
- They are **fast**, and **light**.
- Beta particles have a **medium penetrating power** - they are stopped by a sheet of **aluminium** or plastics such as **perspex**.
- Beta particles ionise atoms that they pass, but not as strongly as alpha particles do.

Gamma rays (What are the gamma rays? Explain their applications CSS 2016)

- Gamma rays are **waves, not particles**. This means that they have **no mass** and **no charge**. So we sometimes write $^0_0\gamma$.
- Gamma rays have a **high penetrating power** - it takes a thick sheet of metal such as **lead**, or **concrete** to reduce them significantly.
- Gamma rays do not directly ionise other atoms, although they may cause atoms to emit other particles which will then cause ionisation.
- We don't find pure gamma sources - gamma rays are emitted alongside alpha or beta particles. Strictly speaking, gamma emission isn't 'radioactive decay' because it doesn't change the state of the nucleus; it just carries away some energy.

Summary

Type of Radiation	Alpha particle	Beta particle	Gamma ray
Symbol	α or $^4_2\alpha$ or ^4_2He	β or β^-	γ *(can look different,depends on the font)*
Mass *(atomic mass units)*	4	1/2000	0
Charge	+2	-1	0
Speed	slow	fast	very fast (*speed of light*)
Ionising ability	high	medium	0
Penetrating power	low	medium	high
Stopped by:	paper	aluminium	lead

Radioactive Half Time

The radioactive half-life for a given radioisotope is the time for half the radioactive nuclei in any sample to undergo radioactive decay. After two half-lives, there will be one fourth the original sample, after three half-lives one eight the original sample, and so forth.

Radioactive Decay

Radioactive decay is the spontaneous breakdown of an atomic nucleus resulting in the release of energy and matter from the nucleus. In the process, they will release energy and matter from their nucleus and often transform into a new element. This process, called **transmutation**, is the change of one element into another as a result of changes within the nucleus. The radioactive decay and transmutation process will continue until a new element is formed that has a stable

nucleus and is not radioactive. Transmutation can occur naturally or by artificial means.

Radioactive or Carbon Dating

Radiometric dating (often called radioactive dating) is a technique used to date materials such as rocks, usually based on a comparison between the observed abundance of a naturally occurring radioactive isotope and its decay products, using known decay rates. The use of radiometric dating was first published in 1907 by Bertram Bolt wood and is now the principal source of information about the absolute age of rocks and other geological features, including the age of the Earth itself, and can be used to date a wide range of natural and man-made materials. Together with stratigraphic principles, radiometric dating methods are used in geochronology to establish the geological time scale. Among the best-known techniques are radiocarbon dating, potassium-argon dating and uranium-lead dating. By allowing the establishment of geological timescales, it provides a significant source of information about the ages of fossils and the deduced rates of evolutionary change. Radiometric dating is also used to date archaeological materials, including ancient artifacts.

Detecting Radioactive Rays

Radioactivity is invisible, has no smell, makes no sound - in fact it cannot be detected by any of our senses.

However, because radioactivity affects the atoms that it passes, we can easily monitor it using a variety of methods:

- Geiger-Müller tube
- Photographic Film
- Gold Leaf Electroscope
- Spark Counter
- Cloud Chamber
- Bubble Chamber
- Modern Detectors

Uses of Radiation

Here are some examples of how radiation is used:

- in smoke detectors
- for sterilizing medical instruments
- for killing cancer cells
- for dating rocks and materials such as archaeological finds
- in chemical tracers to help with medical diagnosis
- for measuring the thickness of materials in, for example, a paper factory

Tracers

Doctors may use radioactive chemicals called tracers for medical imaging. Certain chemicals concentrate in different damaged or diseased parts of the body, and the radiation concentrates with it. Radiation detectors placed outside the body detect the radiation emitted and, with the aid of computers, build up an image of the inside of the body.

When a radioactive chemical is used in this way it is not normally harmful, because:

- it has a short half-life and so decays before it can do much damage
- it is not poisonous

Emitters of beta radiation or gamma radiation are used because these types of radiation readily pass out of the body, and they are less likely to be absorbed by cells than alpha radiation.

Monitoring the thickness of materials

Radiation is used in industry in detectors that monitor and control the thickness of materials such as paper, plastic and aluminium. The thicker the material, the more radiation is absorbed and the less radiation reaches the detector. It then sends signals to the equipment that adjusts the thickness of the material.

Units of Radiation Measurement

- **The gray (Gy)** The gray (Gy) measures the absorbed dose, meaning the energy transferred to the material by ionizing radiation upon encountering it. *1 Gy = 1 joule per kilogram*
- **The Becquerel (Bq)**: The Becquerel (Bq) measures the activity of the radioactive source, meaning the number of atoms which, within a particular time frame, transform and emit radiation. *1 Bq = 1 emission of radiation per second.*
- **The sievert (Sv)** evaluates the effects of ionizing radiation on living material. At equal doses, the effects of radioactivity on living tissue depends on the type of radiation (alpha, beta, gamma, etc.), on the organ concerned and naturally on the length of exposure.
- **Roentgen (R)** A unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions resulting in a charge of 0.000258 coulombs/kilogram of air under standard conditions. Named after Wilhelm Roentgen, the German scientist who discovered x-rays in 1895.
- **Rad (radiation absorbed dose)** The radiation-absorbed dose (rad) is the amount of energy (from any type of ionizing radiation) deposited in any medium (e.g., water, tissue, air) An absorbed dose of 1 rad means that 1 gram of material absorbed 100 ergs of energy (a small but measurable amount) as a result of exposure to radiation.
- **REM (Roentgen equivalent man)** A unit in the traditional system of units that measures the effects of ionizing radiation on humans.

Nuclear Fission

Radioactive elements can undergo a number of different reactions in the process of forming a stable element. Nuclear fission is one such reaction. Fission means to divide. Elements having atomic numbers greater than 90 can undergo fission. Uranium is one such element. In nuclear fission, the nucleus of an atom breaks up.

In other words, heavy unstable nuclides can be split to produce energy in a process called nuclear fission. When uranium decays naturally α - particles and - particles are emitted. However, when uranium - 235 is bombarded by neutron it forms uranium - 236. Uranium - 236 is unstable and breaks down, splitting into two large particles and emitting three neutrons.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3(^{1}_{0}n)$$

When the exact masses of the final products are added together, the sum is found to be appreciably less than the sum of the exact masses of the uranium - 235 and the original neutron.

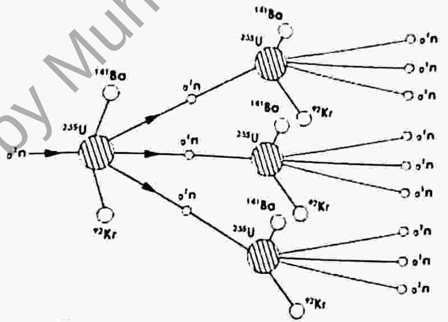
This difference in mass Δm appears as energy given by $\Delta E = \Delta mc^2$, [c is the velocity of light]

The Uranium - 236 can fission to give isotopes of Barium-144, Krypton - 90 and two neutrons.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{144}_{56}Ba + ^{90}_{36}Kr + 2(^{1}_{0}n)$$

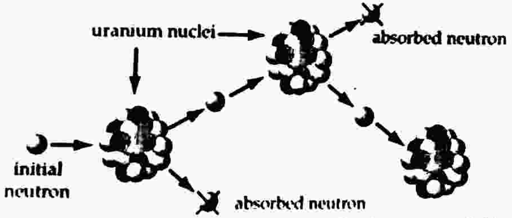
Nuclear Chain Reaction

Fission in uranium atoms may result in a chain reaction. A nuclear chain reaction is a series of rapid nuclear fissions. A small sample of uranium contains billions of atoms. When one uranium - 235 nucleus is split by a neutron, it releases two neutrons. The two neutrons are used to split two more uranium nuclei. Each nuclei, causing them to split. The fission of nuclei and release of neutrons becomes a chain reaction. In a chain reaction, billions of fission reaction may occur per second.



Controlled Nuclear Fission

To maintain a sustained controlled nuclear reaction, for every 2 or 3 neutrons released, only one must be allowed to strike another uranium nucleus. If this ratio is less than one then the reaction will die out; if it is greater than one it will grow uncontrolled (an atomic explosion). A neutron absorbing element must be present to control the amount of free neutrons in the reaction space. Most reactors are controlled by means of control rods that are made of a strongly neutron-absorbent material such as boron or cadmium.



In addition to the need to *capture* neutrons, the neutrons often have too much kinetic energy. These *fast neutrons* are slowed through the use of a moderator such as heavy water and ordinary water. Some reactors use graphite as a moderator, but this design has several problems. Once the fast neutrons have been slowed, they are more likely to produce further nuclear fissions or be absorbed by the control rod.

Uranium Enrichment (CSS 2009)

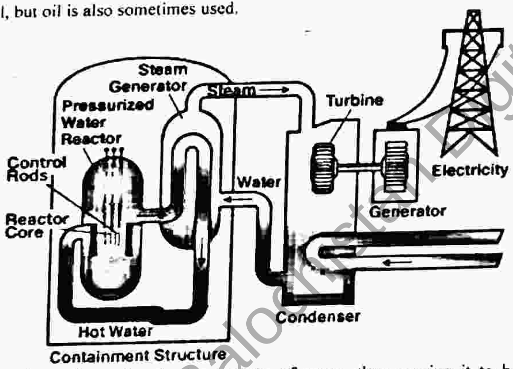
Scientists knew that the most common isotope, uranium 238, was not suitable for a nuclear weapon. There is a fairly high probability that an incident neutron would be captured to form uranium 239 instead of causing fission. However, uranium 235 has a high fission probability.

Of natural uranium, only 0.7% is uranium 235. This meant that a large amount of uranium was needed to obtain the necessary quantities of uranium 235

In order for a chain reaction to occur, the pure uranium ore must be refined to raise the concentration of 235U. This is called enrichment and is primarily accomplished through a technique called gaseous diffusion. In this process, the uranium ore is combined with fluorine to create a chemical compound called uranium hexafluoride. The uranium hexafluoride is heated and vaporizes. The heated gas is then pushed through a series of filters. Because some of the uranium hexafluoride contains 238U and some contains 235U, there is a slight difference in the weights of the individual molecules. The molecules of uranium hexafluoride containing 235U are slightly lighter and thus pass more easily through the filters. This creates a quantity of uranium hexafluoride with a higher proportion of 235U. This is collected, the uranium is stripped from it, and the result is an enriched supply of fuel. Usually, nuclear power plants use uranium fuel that is about 4% 235U.

Nuclear Power Plant

A nuclear power plant produces electricity in almost exactly the same way that a conventional (fossil fuel) power plant does. A conventional power plant burns fuel to create heat. The fuel is generally coal, but oil is also sometimes used.



The heat is used to raise the temperature of water, thus causing it to boil. The high temperature and intense pressure steam that results from the boiling of the water turns a turbine, which then generates electricity. A nuclear power plant works the same way, except that the heat used to boil the water is produced by a nuclear fission reaction using 235U as fuel, not the combustion of fossil fuels. A nuclear power plant uses much less fuel than a comparable fossil fuel plant. A rough estimate is that it takes 17,000 kilograms of coal to produce the same amount of electricity as 1 kilogram of nuclear uranium fuel.

Advantages of Nuclear Energy

- Nuclear power plants don't require a lot of **space** - they have to be built on the coast, but do not need a large plot like a wind farm.
- It doesn't contribute to **carbon emissions** - no CO_2 is given out - it therefore does not cause global warming.
- It does not produce **smoke particles** to pollute the atmosphere.
- Nuclear energy is by far the most **concentrated form of energy** - a lot of energy is produced from a small mass of fuel. This **reduces transport costs** - (although the fuel is radioactive and therefore each transport that does occur is expensive because of security implications).
- It is **reliable**. It does not depend on the weather. We can control the output It is relatively easy to control the output - although the time factor for altering power output is not as small as for fossil fuel stations.
- It produces a **small volume of waste**

Disadvantages

- **Disposal of nuclear waste** is very expensive. As it is radioactive it has to be disposed of in such a way as it will not pollute the environment.
- **Decommissioning** of nuclear power stations is expensive and takes a long time.
- **Nuclear accidents** can spread radiation producing particles over a wide area. This radiation harms the cells of the body which can make humans sick or even cause death. Illness can appear or strike people years after they were exposed to nuclear radiation and genetic problems can occur too. A possible type of reactor disaster is known as **meltdown**. In a meltdown, the fission reaction of an atom goes out of control, which leads to a nuclear explosion releasing great amounts of radioactive particles into the environment

Nuclear Fission

When lighter nuclides fuse together to form a heavy nucleus in a process called nuclear fusion, energy is produced and mass is lost. For example, two atoms of heavy hydrogen may fuse together to form helium and a neutron:

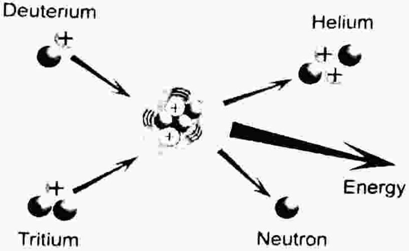
$$^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{3}_{2}H + ^{1}_{0}n$$

The sum of the exact masses of the helium atom and the neutron is less than the sum of exact masses of the two heavy hydrogen atoms. This lost mass is released as energy.

It is thought that the Sun's energy is produced by nuclear fusion. The two heavy hydrogen atoms must move with great speed in order to overcome the strong repulsive forces between the positively charged nuclei. The very high temperatures required for fusion reactions would melt any known material. Therefore, the atoms are held in a plasma (hot ionized gas) in an intense magnetic field so that they do not touch the walls of the container. It has not yet been possible to produce a controlled reaction, but in future this problem may well be overcome. An uncontrolled fusion reaction has been produced in the hydrogen bomb.

Nuclear fusion is the opposite of nuclear fission. Elements with small masses combine to form elements with larger masses.

The temperature conditions for fusion exists in the sun and stars. The sun has an internal temperature of about 20,000,000°C. In the sun, fusion occurs through a complex series of nuclear changes. During the early life of a star, four hydrogen nuclei are fused into one helium nucleus in a series of steps.



The sun is constantly losing hydrogen as it forms helium. A tremendous amount of energy is released during this fusion. The energy comes from matter that is converted to energy. The helium that is formed has a mass almost one percent less than the mass of the four hydrogen atoms. This one percent mass is converted to energy.

Light and radiant energy from nuclear fusion travel 150 million kilometers from the sun to the earth. However, the total energy that reaches the earth is only a tiny fraction of the total energy released by the sun.

Nuclear Fission vs Nuclear Fusion

Nuclear fusion and nuclear fission are two different types of energy-releasing reactions in which energy is released from high-powered atomic bonds between the particles within the nucleus. The main difference between these two processes is that fission is the splitting of an atom into two or more smaller ones while fusion is the fusing of two or more smaller atoms into a larger one.

	Nuclear Fission	Nuclear Fusion
Definition:	Fission is the splitting of a large atom into two or more smaller ones	Fusion is the fusing of two or more lighter atoms into a larger one.
Natural occurrence of the process	Fission reaction does not normally occur in nature.	Fusion occurs in stars, such as the sun.
Byproducts of the reaction:	Fission produces many highly radioactive particles	Few radioactive particles are produced by fusion reaction, but if a fission "trigger" is used, radioactive particles will result from that.
Conditions:	Critical mass of the substance and high-speed neutrons are required	High density, high temperature environment is required.
Energy Requirement:	Takes little energy to split two atoms in a fission reaction.	Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion.
Energy Released:	The energy released by fission is a million times greater than that released in chemical reactions; but lower than the energy released by nuclear fusion	The energy released by fusion is three to four times greater than the energy released by fission
Nuclear weapon:	One class of nuclear weapon is a fission bomb, also known as an atomic bomb or atom bomb.	One class of nuclear weapon is the hydrogen bomb, which uses a fission reaction to "trigger" a fusion reaction

Radioactive Pollution

What is Radioactive Pollution? Radioactive pollution, like any other kind of pollution, is the release of something unwanted into the environment and, in this case, the unwanted thing is radioactive material. Radioactive pollution can be a very dangerous thing because radiation mutates DNA, causing abnormal growth and possibly cancer, and this radiation remains in the atmosphere for years, slowly diminishing over time. There are many causes of radioactive pollution, which can significantly harm the environment. There are techniques used to manage this pollution, however, we are far from keeping our planet clean of radioactive pollution.

Causes of Radioactive Pollution

There are many causes of radioactive pollution. The causes are, as you may have guessed, radioactive substances or, more accurately, radioactive waste but only when improperly disposed of. If radioactive waste is disposed of in the appropriate manner then it does not contribute towards radioactive pollution. The causes are as follows:

1. **Production of nuclear weapons** - radioactive materials used in this production have high health risks and release a small amount of pollution. Thanks to good current health-standards this release is not significant and is not a danger to us unless an accident occurs. Standards have not always been so high, however, as in Fernald, Ohio USA.
2. **Decommissioning of nuclear weapons** - the decommissioning of nuclear weapons causes slightly more radioactive pollution than in the production, however, the waste (alpha particles) is still of low risk and not dangerous unless ingested.
3. **Mining of radioactive ore** (uranium, phosphate etc.) - mining these involves crushing and processing of the radioactive ores and this generates radioactive waste which emits alpha particles. This waste is of low risk unless ingested.
4. **Coal ash** - it may come as a surprise that coal ash can be very dangerous. Some coal contains more radioactive material than usual and is often referred to as 'dirty' coal; when this is burnt the ash becomes more radioactive as the radioactive particles do not burn well. This level of radioactivity is less than in phosphate rocks, however, due to small amounts being released into the atmosphere and its ability to be inhaled, this ash is significantly more dangerous.
5. **Medical waste** - a number of radioactive isotopes are used in medicine, either for treatment or diagnostics. These can be left to decay over a short period after which they are able to be disposed of as normal waste.
6. **Nuclear power plants** - nuclear power plants under current standards produce little radioactive pollution due to safety precautions that must be adhered to. Accidents at these power plants can cause dangerously high radioactive pollution, such as in the case of Chernobyl, the most well-known and worst nuclear disaster in history and the more recent Fukushima, after the earthquake and tidal wave in Japan.

Electromagnetic Radiation

Electromagnetic radiation is a form of energy that is produced by oscillating electric and magnetic disturbance, or by the movement of electrically charged particles traveling through a vacuum or matter. The electric and magnetic fields come at right angles to each other and combined wave moves perpendicular to both magnetic and electric oscillating fields thus the disturbance. Electron radiation is released as photons, which are bundles of light energy that travel at the speed of light as quantized harmonic waves. This energy is then grouped into categories based on its wavelength into the electromagnetic spectrum. These electric and magnetic waves travel perpendicular to each other and have certain characteristics, including amplitude, wavelength, and frequency.

General Properties of all electromagnetic radiation:

1. Electromagnetic radiation can travel through empty space. Most other types of waves must travel through some sort of substance. For example, sound waves need either a gas, solid, or liquid to pass through in order to be heard.
2. The speed of light is always a constant. (Speed of light : 2.99792458 x 10^8 m s^{-1})
3. Wavelengths are measured between the distances of either crests or troughs. It is usually characterized by the Greek symbol λ

Light Wave

A *wave* is a disturbance or oscillation that travels through space and matter, accompanied by a transfer of energy. *Wave motion* transfers energy from one point to another, often with no permanent displacement of the particles of the medium—that is, with little or no associated mass transport. They consist, instead, of oscillations or vibrations around almost fixed locations. Waves are described by a wave equation which sets out how the disturbance proceeds over time. The mathematical form of this equation varies depending on the type of wave.

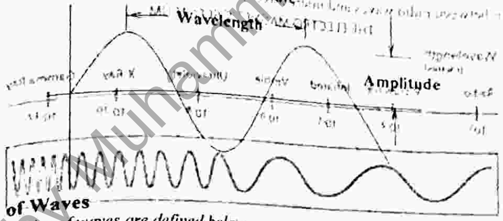
There are two main types of waves.

- **Mechanical waves** propagate through a medium, and the substance of this medium is deformed. The deformation reverses itself owing to restoring forces resulting from its deformation. For example, sound waves propagate via air molecules colliding with their neighbors. When air molecules collide, they also bounce away from each other (a restoring force). This keeps the molecules from continuing to travel in the direction of the wave.
- **Electromagnetic waves** do not require a medium. Instead, they consist of periodic oscillations of electrical and magnetic fields generated by charged particles, and can therefore travel through a vacuum. These types of waves vary in wavelength, and include radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

Further, the behavior of particles in quantum mechanics is described by waves and researchers believe that gravitational waves also travel through space, although gravitational waves have never been directly detected.

A wave can be transverse or longitudinal depending on the direction of its oscillation. Transverse waves occur when a disturbance creates oscillations perpendicular (at right angles) to the propagation (the direction of energy transfer). Longitudinal waves occur when the oscillations are parallel to the direction of propagation. While mechanical waves can be both transverse and longitudinal, all electromagnetic waves are transverse. A simple type of wave is illustrated below.

A simple wave



Properties of Waves

The main properties of waves are defined below

- **Amplitude:** the height of the wave, measured in meters.
- **Wavelength: the distance between adjacent crests, measured in meters.**
- **Period:** the time it takes for one complete wave to pass a given point, measured in seconds.
- **Frequency:** the number of complete waves that pass a point in one second, measured in inverse seconds, or **Hertz** (Hz).
- **Speed:** the horizontal speed of a point on a wave as it propagates, measured in meters / second.

Not all of these properties are independent; one has the relations

- Period = 1 / frequency
- Speed = wavelength / period = wavelength x frequency

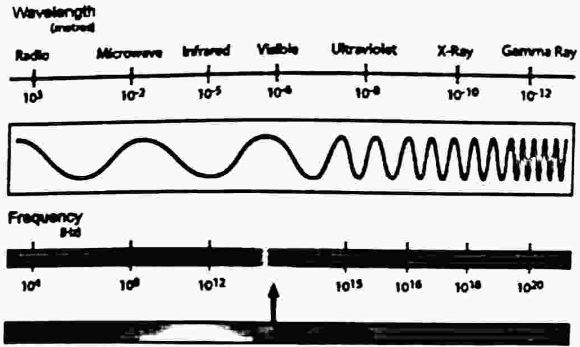
Difference between Mechanical and Electromagnetic Waves

Electromagnetic Waves	Mechanical Waves
An electromagnetic wave is called just a disturbance	A mechanical wave is considered a periodic disturbance.
Electromagnetic waves travel in a vacuum	Mechanical wave is that which needs some medium for traveling.
Electromagnetic waves are caused because of the varying magnetic and electric fields	Mechanical waves are caused by wave amplitude and not by frequency
Examples of electromagnetic waves include light and radio signals.	The ripples made in a pool of water after a stone is thrown in the middle are an example of mechanical wave.
Electromagnetic waves have high speed	mechanical wave have low speed

The Electromagnetic Spectrum

The "electromagnetic spectrum" is simply a phrase used to describe *electromagnetic radiation* of all wavelengths. This includes radio waves, microwaves, infrared, visible light. ultraviolet, x rays, gamma rays, and other electromagnetic radiation of longer and shorter wavelengths. Note that the names given to various portions of the spectrum are simply arbitrary labels imposed by humans; there is no definite wavelength where "radio waves" cease to be radio waves and suddenly become "microwaves". Rather, the various portions of the spectrum blend into one another and waves in between radio waves and microwaves interact with matter in a manner in between radio waves and microwaves.

THE ELECTRO MAGNETIC SPECTRUM



It is important to remember that there is no fundamental difference between any portion of the electromagnetic spectrum other than wavelength (and its dependent properties, frequency and energy). A radio wave is electromagnetic radiation of a long wavelength, and x rays are electromagnetic radiation of a shorter wavelength, but they are both electromagnetic radiation and their behavior is governed by the same laws.

Likewise, infrared radiation is of wavelengths that are easily absorbed by matter and turned into heat, and x rays are radiation of wavelengths that can pass through soft tissue but are stopped by bone. The wonderful variety of the electromagnetic spectrum is all a result of the same laws, applied to different wavelengths and energies.

The entire electromagnetic spectrum has frequencies between less than 1 billion waves per second (radio) and greater than 3 billion waves per second (gamma rays). Light waves are waves of energy and the amount of energy in a wave is proportional to its frequency. Wavelength increases, while frequency and energy decreases as we go from gamma rays to radio waves.

Plane Mirrors

Plane mirrors are the common, every day, flat mirrors that we see everywhere in our society. A plane mirror consists of a flat, two-dimensional surface that reflects the light coming from or reflecting off another object. When light rays strike this particular mirror, the angle of reflection (the light ray's incoming angle) is equal to the angle of incidence (the light ray's outgoing angle). The object reflected will appear to be behind the mirror's surface at the identical distance away.

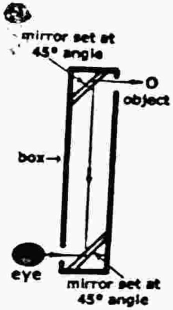
For flat mirrors the Law of Plane Mirrors states that "the image is always the same distance behind the mirror as the object is in front of the mirror." The image, I, and the object, O, always line up along the same normal. The image is upright, but left-right reversed. The Law of Plane Mirrors states that $d_i = -d_o$. This reflection, like ALL reflections, obeys the Law of Reflection: the angle of incidence equals the angle of reflection. Note that these angles are measured from the normal to either the incident or reflected rays. The minimum length of a plane mirror required for someone to view their entire image equals half their height. Note that the top of the mirror should be placed at eye level. The size of the image equals the size of the object; that is, the magnification of a plane mirror equals one. Recall that magnification is calculated using the formula:

$$M = \left|\frac{d_i}{d_o}\right| = \left|\frac{I}{O}\right|$$

Use of plane mirrors

1. Plane mirrors are used as looking glass.
2. Plane mirrors also have many scientific uses. In most of the measuring instruments
3. Plane mirrors are also used in constructing periscope which is used in submarines.
4. Plane mirrors are used in solar cookers.
5. Plane mirrors are used to make kaleidoscope, a toy which produces beautiful patterns from colored paper, pieces of glass or small colored beads.

Application of Plane Mirrors-Periscope

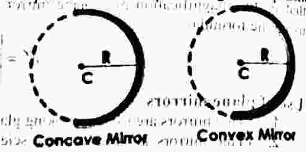


It is an instrument in which plane mirrors are used to fold light so that the image of an object can be brought down to a lower level. It is used for observing enemy movements from trenches without any danger of being seen. Sailors on submarines use periscopes to see things above the water level.

It consists of two parallel mirrors A and B facing each other and each fixed at 45° to the frame work. Rays of light entering through the aperture, strike the mirror A at an angle of incidence equal to 45° and are reflected along the axis of the tube, striking the mirror B at 45°. From the mirror B, these rays are reflected parallel to their original path reaching the eyes of the observer.

Spherical Mirror *for* Reflection

A mirror whose polished, reflecting surface is a part of a hollow sphere of glass or plastic is called a spherical mirror.

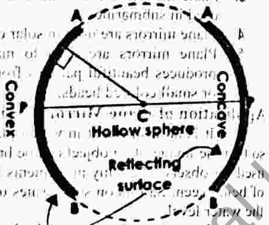


In a spherical mirror, one of the two curved surfaces is coated with a thin layer of silver followed by a coating of red lead oxide paint. Thus, one side of the spherical mirror is opaque and the other side is a highly polished reflecting surface. In a diagram the opaque side of a mirror is always shown shaded.

The reflecting side is black.

Depending upon the nature of the reflecting surface of a mirror, the spherical mirror is classified as:

- Concave mirror
- Convex mirror



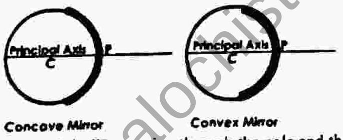
Concave mirror is a spherical mirror whose reflecting surface is towards the center of the sphere of which the mirror is a part.

Convex mirror is a spherical mirror whose reflecting surface is away from the center of the sphere of which the mirror is a part.

Physical Terms

Let us now define certain physical terms relating to spherical mirrors.

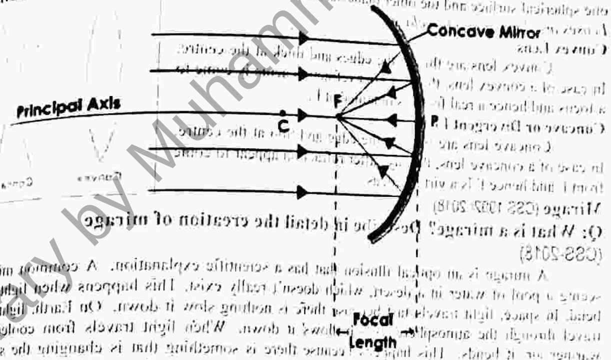
- **Center of Curvature** is the center of the sphere of which the spherical mirror forms a part. It is denoted by the letter C.
- **Radius of Curvature** is the radius of the sphere of which the mirror is a part. It is represented by the letter R.
- **Linear aperture** is the distance between the extreme points (X and Y) on the periphery of the mirror.
- Pole is the midpoint of the aperture of the spherical mirror. It is represented by the letter P.



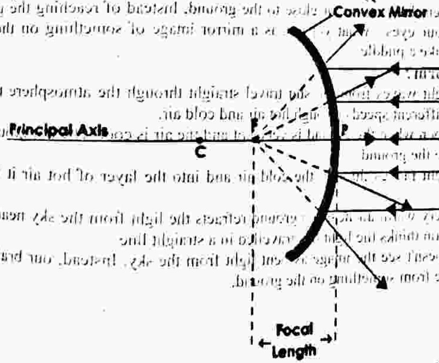
- **Principal axis** is the straight line passing through the pole and the center of curvature of a spherical mirror.

Principal Focus or Focus

The rays of light parallel to the principal axis of a mirror after reflection, either pass through a point (in case of a concave mirror) or appear to diverge from a point (in the case of a convex mirror) on the principal axis and this point is referred to as the principal focus or focal point of the mirror.



Focal length Focal length is the distance between the pole and the focus of a mirror. It is represented by the letter f.



Note : A concave mirror is also known as a converging mirror as the parallel rays of light after getting reflected from the concave mirror converge at the focus.

A convex mirror is known as a diverging mirror as the parallel rays of light after reflection appear to come from a point, i.e., the rays diverge after reflection.

Classification of Lenses

Lens is a portion of transparent refracting medium bound by two spherical surfaces or one spherical surface and the other plane surface.

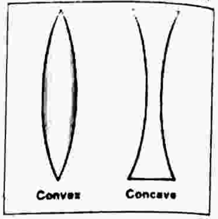
Lenses are divided into two classes:

Convex Lens

Convex lens are thin at the edges and thick at the centre. In case of a convex lens, the rays after refraction actually come to a focus and hence a real focus is obtained at F.

Concave or Divergent Lens

Concave lens are thick at the edge and thin at the centre. In case of a concave lens, the rays after refraction appear to come from F and hence F is a virtual focus



Mirage (CSS 1992/ 2018)

Q: What is a mirage? Describe in detail the creation of mirage

(CSS-2018)

A mirage is an optical illusion that has a scientific explanation. A common mirage is seeing a pool of water in a desert, which doesn't really exist. This happens when light beams bend. In space, light travels fast because there is nothing slow it down. On Earth, light has to travel through the atmosphere, which slows it down. When light travels from cooler air to warmer air, it bends. This happens because there is something that is changing the speed at which the light is traveling. One part of the light wave changes speed just a split second before the other. That makes the light wave turn. Under certain conditions, usually on hot sunny days, light beams bend when they hit hot air close to the ground. Instead of reaching the ground they bounce up toward your eyes. What you see is a mirror image of something on the ground, a reflection that looks like a puddle.

How do mirages form?

Normally, light waves from the sun travel straight through the atmosphere to your eye. But, light travels at different speeds through hot air and cold air.

Mirages happen when the ground is very hot and the air is cool. The hot ground warms a layer of air just above the ground.

When the light moves through the cold air and into the layer of hot air it is **refracted** (bent).

A layer of very warm air near the ground refracts the light from the sky nearly into a U-shaped bend. Our brain thinks the light has travelled in a straight line.

Our brain doesn't see the image as bent light from the sky. Instead, our brain thinks the light must have come from something on the ground.

Ceramic

(CSS 1996, 2001, 2007, 2008)

A ceramic is an inorganic non-metallic solid made up of either metal or non-metal compounds that have been shaped and then hardened by heating to high temperatures. They are typically crystalline in nature and are compounds formed between metallic and nonmetallic elements such as aluminum and oxygen (alumina-Al_2O_3), calcium and oxygen (calcia - CaO), and silicon and nitrogen (silicon nitride-Si_3N_4) In general, they are hard, corrosion-resistant and brittle.

Ceramic comes from the Greek word meaning 'pottery'. (*Pottery is one of the oldest human technologies. Fragments of clay pottery found recently in Hunan Province in China have been carbon dated to 17,500–18,300 years old.*) The clay-based domestic wares, art objects and building products are familiar to us all, but pottery is just one part of the ceramic world.

Nowadays the term 'ceramic' has a more expansive meaning and includes materials like glass, advanced ceramics and some cement systems as well.

Ceramics can be divided into two classes: traditional ceramics and advanced ceramics.

- **Traditional ceramics** include clay products, silicate glass and cement
- **Advanced ceramics** consist of carbides (SiC), pure oxides (Al2O3), nitrides (Si3N4), non-silicate glasses and many others.

Properties

Ceramics offer many advantages compared to other materials. They are harder and stiffer than steel; more heat and corrosion resistant than metals or polymers; less dense than most metals and their alloys; and their raw materials are both plentiful and inexpensive. Ceramic materials display a wide range of properties which facilitate their use in many different product areas

In general, most ceramics are:

1. Hard,
2. Wear-resistant,
3. Brittle,
4. Refractory,
5. Thermal insulators,
6. Electrical insulators,
7. Nonmagnetic,
8. Oxidation resistant,
9. Prone to thermal shock, and
10. Chemically stable.

Applications

Ceramics offer many advantages compared to other materials. They are harder and stiffer than steel; more heat and corrosion resistant than metals or polymers; less dense than most metals and their alloys; and their raw materials are both plentiful and inexpensive. Ceramic materials display a wide range of properties which facilitate their use in many different product areas.

- **Aerospace**: space shuttle tiles, thermal barriers, high temperature glass windows, fuel cells
- **Consumer Uses**: glassware, windows, pottery, Coming™ ware, magnets, dinnerware, ceramic tiles, lenses, home electronics, microwave transducers
- **Automotive**: catalytic converters, ceramic filters, airbag sensors, ceramic rotors, valves, spark plugs, pressure sensors, thermistors, vibration sensors, oxygen sensors, safety glass

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windshields, piston rings

- **Medical** (*Bioceramics*): orthopedic joint replacement, prosthesis, dental restoration, bone implants
- **Military**: structural components for ground, air and naval vehicles, missiles, sensors
- **Computers**: Insulators, resistors, superconductors, capacitors, ferroelectric components, microelectronic packaging
- **Other Industries**: bricks, cement, membranes and filters, lab equipment
- **Communications**: fiber optic/laser communications, TV and radio components, microphones

Classifications of Technical Ceramics

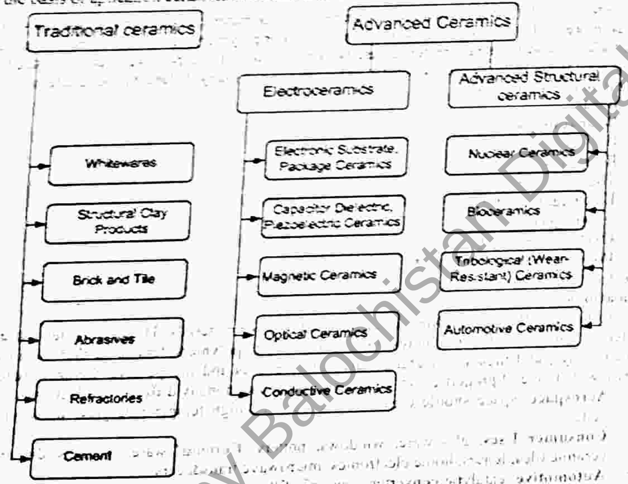
Technical Ceramics can also be classified into three distinct material categories:

a) **Oxides**: Alumina, zirconia
b) **Non-oxides**: Carbides, borides, nitrides, silicides
c) **Composites**: Particulate reinforced combinations of oxides and non-oxides.

Each one of these classes can develop unique material properties.

Application Base Classification of Ceramics Materials

There are various classification systems of ceramic materials, which may be attributed to one of two principal categories: application base system or composition base system. On the basis of aplication ceramics classified into Traditional and Advanced Ceramics



Plastics

(CSS 2008,2009)

Plastics, materials made up of large, organic (carbon-containing) molecules that can be formed into a variety of products. The molecules that compose plastics are long carbon chains that give plastics many of their useful properties. In general, materials that are made up of long, chainlike molecules are called polymers. The word plastic is derived from the words plasticus ("capable of molding") and plastikos (Greek "to mold," or "fit for molding"). Plastics can be made hard as stone, strong as steel, transparent as glass, light as wood, and elastic as rubber. Plastics are also lightweight, waterproof, chemical resistant, and produced in almost any color. More than 50 families of plastics have been produced, and new types are currently under development. All plastics are polymers, but not all polymers are plastics.

Plastic Properties

Plastics have numerous properties that make them superior to other materials in many applications. Plastics generally have:

- Resistance to corrosion and chemicals
- Low electrical and thermal conductivity
- High strength-to-weight ratio
- Colors available in a wide variety and transparent
- Resistance to shock
- Good durability
- Low cost
- Easy of manufacture
- Resistance to water
- Low toxicity

Applications of Plastic

Plastics are one of the most common materials in countless products and applications including:

- Appliances
- Auto interior panels, side shields, fender liners, head liners
- Bottles
- CD and cassette boxes
- Cutlery
- Displays
- Disposable cups
- Electrical connectors
- Electronic enclosures
- Eyeglasses
- Food packaging
- Fridge liners
- ID cards
- Instrument panels
- Jars
- Lenses
- Microwavable packaging

- Name tags
- Outdoor signs
- Packaging
- Pallets
- Pipes
- Plates
- Seat backs
- Security shields
- Shutters
- Trays
- Window frames
- Windows
- Windshields

Chemistry of Plastics

Plastics consist of very long molecules each composed of carbon atoms linked into chains. One type of plastic, known as, is composed of extremely long molecules that each contains over 200,000 carbon atoms. These long, chainlike molecules give plastics unique properties and distinguish plastics from materials, such as metals, that have short, crystalline molecular structures.

Although some plastics are made from plant oils, the majority are made from fossil fuels. Fossil fuels contain hydrocarbons, which provide the building blocks for long polymer molecules. These small building blocks, called monomers, link together to form long carbon chains called polymers. The process of forming these long molecules from hydrocarbons is known as polymerization. The molecules typically form viscous, sticky substances known as resins, which are used to make plastic products.

Thermosetting and Thermoplastic Plastics

There are two basic types of plastic: *thermosetting*, which cannot be resoftened after being subjected to heat and pressure; and *thermoplastic*, which can be repeatedly softened and remolded by heat and pressure. When heat and pressure are applied to a thermoplastic binder, the chainlike polymers slide past each other, giving the material "plasticity." However, when heat and pressure are initially applied to a thermosetting binder, the molecular chains become cross-linked, thus preventing any slippage if heat and pressure are reapplied.

Difference between Thermosetting and Thermoplastic Plastics

Though thermoset plastics and thermoplastics sound similar, they have very different properties and applications. Understanding the performance differences can help you make better sourcing decisions and improve your product designs.

The primary physical difference is that thermoplastics can be remelted back into a liquid, whereas thermoset plastics always remain in a permanent solid state. Think of thermoplastics as butter – butter can be melted and cooled multiple times to form various shapes. Thermoset is similar to bread in that once the final state is achieved, any additional heat would lead to charring.

Thermoset	Thermoplastic
Thermoset Curing Process Thermoset plastics contain polymers that cross-link together during the curing process to form an irreversible chemical bond. The cross-linking process eliminates the risk of the product remelting when heat is applied, making thermosets ideal for high-heat applications such as electronics and appliances	**Thermoplastics Curing Process** Thermoplastics pellets soften when heated and become more fluid as additional heat is applied. The curing process is completely reversible as no chemical bonding takes place. This characteristic allows thermoplastics to be remolded and recycled without negatively affecting the material's physical properties.
Features and Benefits Thermoset plastics significantly improve the material's mechanical properties, providing enhances chemical resistance, heat resistance and structural integrity. Thermoset plastics are often used for sealed products due to their resistance to deformation.	**Features and Benefits** There are multiple thermoplastic resins that offer various performance benefits, but most materials commonly offer high strength, shrink-resistance and easy bendability. Depending on the resin, thermoplastics can serve low-stress applications such as plastic bags or high-stress mechanical parts
Pro ○ More resistant to high temperatures than thermoplastics ○ Highly flexible design ○ Thick to thin wall capabilities ○ Excellent aesthetic appearance ○ High levels of dimensional stability ○ Cost-effective	**Pro** ○ Highly recyclable ○ Aesthetically-superior finishes ○ High-impact resistance ○ Remolding/reshaping capabilities ○ Chemical resistant ○ Hard crystalline or rubbery surface options ○ Eco-friendly manufacturing
Cons ○ Cannot be recycled ○ More difficult to surface finish ○ Cannot be remolded or reshaped	**Cons** ○ Cannot be recycled ○ More difficult to surface finish ○ Cannot be remolded or reshaped

Importance and Usage of Plastics

Plastics are indispensable to our modern way of life. Many people sleep on pillows and mattresses filled with a type of plastic—either cellular polyurethane or polyester. At night, people sleep under blankets and bedspreads made of acrylic plastics, and in the morning, they step out of bed onto polyester and nylon carpets

The cars we drive, the computers we use, the utensils we cook with, the recreational equipment we play with, and the houses and buildings we live and work in all include important plastic components. The average car contains almost 136 kg (almost 300 lb) of plastics—nearly 12 percent of the vehicle's overall weight. Telephones, textiles, compact discs, paints, plumbing fixtures, boats, and furniture are other domestic products made of plastics.

Plastics are used extensively by many key industries, including the automobile, aerospace, construction, packaging, and electrical industries. The aerospace industry uses plastics to make strategic military parts for missiles, rockets, and aircraft. Plastics are also used in specialized fields, such as the health industry, to make medical instruments, dental fillings, optical lenses, and biocompatible joints.

Advantages of plastic:

Some of advantages of plastics are listed below;

- ○ Generally plastic items like toys, bags can be reused in various ways such as in the manufacturing of fashionable accessories and other plastic goods.

- Plastic materials are light in weight, unbreakable, odorless and can be easily molded.
- They have excellent finishing; possess good shock absorption capacity, high strength as well as toughness.
- The plastics materials are corrosion resistant and these are inert as far chemical or changes due to atmospheric oxygen goes; besides these have low thermal expansion of co-efficient.
- Therefore they possess good thermal and electrical insulating property.
- Plastics have water resistant property and possess good adhesiveness. They are strong, durable, good and cheap to produce.
- It is possible to recycle plastic; therefore no decomposition required which is much more expensive and hazardous than recycling.
- Plastic can be used in building, construction, electronics, packing and transportation industries.
- Plastic can be used to produce other product and reduce soil and wind erosion.
- Because of nonconductive nature of plastic, they can be easily use in electrical installations.

Disadvantages of plastics:

- Plastic is a soft, non-renewable resources which cannot be used for some crucial applications.
- The poisonous gaseous product produced by the decomposition plastic can causes CANCER
- They are ombrittlement at low temperature and deformation at high pressure.
- Plastic materials have low heat resistant and poor ductility. But they are combustibility and release toxic fumes after burning.
- The recycling of plastic is not cost effective process and even more expensive compare to its manufacturing.
- The raw material for manufacturing of plastic bags is petrochemicals which are non-renewable resource.
- Plastic bags are flimsy and not durable like paper or cloth.
- The improper disposal of plastic can cause hazard to wildlife as they are not readily biodegradable.
- Plastic materials like plastic bags are mostly end up as harmful waste in landfill which may pollute the environment and threatening our health.
- The biodegradation of plastic takes 500 to 1,000 years but manufacturing takes only seconds.

Plastic and the Environment

Plastics are used throughout the world for a broad number of reasons. Although plastic is certainly a globally important product, there are many environmental concerns associated with its use

Impacting the Environment

One of the positive characteristics of plastic is the fact that it is durable. Unfortunately, this is not a positive characteristic when it comes to the environment. The fact that plastic is durable means it degrades slowly. In addition, burning plastic can sometimes result in toxic fumes.

Aside from trying to get rid of plastic, creating it can be costly to the environment as

well. It takes large amounts of chemical pollutants to create plastic, as well as significant amounts of fossil fuels.

On the other hand, some argue that plastic helps the environment is several ways, as well. After all, plastic has been used to make cars lighter. As a result, less oil is used to mobilize the cars and less CO2 is emitted. In addition, plastic containers provide safe ways for disposing of toxic waste products.

From cell phones and computers to bicycle helmets and hospital IV bags, plastic has molded society in many ways that make life both easier and safer. But the synthetic material also has left harmful imprints on the environment and perhaps human health

One of the most ubiquitous and long-lasting recent changes to the surface of our planet is the accumulation and fragmentation of plastics

Since its mass production began in the 1940s, plastic's wide range of unique properties has propelled it to an essential status in society. Next year, more than 300 million tons will be produced worldwide. The amount of plastic manufactured in the first ten years of this century will approach the total produced in the entire last century

Plastics are very long-lived products that could potentially have service over decades, and yet our main use of these lightweight, inexpensive materials are as single-use items that will go to the garbage dump within a year, where they'll persist for centuries

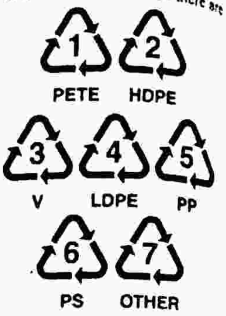
Evidence is mounting that the chemical building blocks that make plastics so versatile are the same components that might harm people and the environment. And its production and disposal contribute to an array of environmental problems, too. For example:

- Chemicals added to plastics are absorbed by human bodies. Some of these compounds have been found to alter hormones or have other potential human health effects.
- Plastic debris, laced with chemicals and often ingested by marine animals, can injure or poison wildlife.
- Floating plastic waste, which can survive for thousands of years in water, serves as mini transportation devices for invasive species, disrupting habitats.
- Plastic buried deep in landfills can leach harmful chemicals that spread into groundwater.
- Around 4 percent of world oil production is used as a feedstock to make plastics, and a similar amount is consumed as energy in the process.
- People are exposed to chemicals from plastic multiple times per day through the air, dust, water, food and use of consumer products. *For example*, phthalates are used as plasticizers in the manufacture of vinyl flooring and wall coverings, food packaging and medical devices. Eight out of every ten babies, and nearly all adults, have measurable levels of phthalates in their bodies.
- In addition, bisphenol A (BPA), found in polycarbonate bottles and the linings of food and beverage cans, can leach into food and drinks. The U.S. Centers for Disease Control and Prevention reported that 93 percent of people had detectable levels of BPA in their urine.

Type *of* Plastics *and* Plastic Recycling

Plastic is a material, which degrades very slowly. It is said that, it takes around 100 to 500 years for discarded plastic to get degraded naturally. This revelation led to the concept of plastic recycling, which was promoted by almost all nations. However, this method confronted various hurdles and one among them was the different types of plastic that required different methods of recycling. There was no universal standard to classify plastic, which is used in various products.

It was in 1988, the SPI (*The Society of the Plastics Industry*) designed the symbol code for plastic classification. The symbol code consists of a triangle of arrows, inside which there are numbers ranging from 1 to 7. Most of us are familiar with this symbol embossed on plastic items like pet bottles, yogurt cups, etc. This system of classifying plastic is considered to be a uniform coding system, which helps both consumers and recyclers to differentiate the various kinds of plastic. Apart from that, it gives a clear idea about which plastic is used for manufacturing that product.



Number 1 Plastics

PET *or* **PETE** (*polyethylene terephthalate*)

Polyethylene terephthalate ethylene found in Soft drink, water and beer bottles; mouthwash bottles; peanut butter containers; salad dressing and vegetable oil containers; oven able food trays.

Number 2 Plastics

HDPE (*high density polyethylene*)

High density polyethylene, found in Milk jugs, juice bottles; bleach, detergent and household cleaner bottles; shampoo bottles; some trash and shopping bags; motor oil bottles; butter and yogurt tubs; cereal box liners

Number 3 Plastics

V (Vinyl) *or* **PVC**

Polyvinyl chloride, found in. Window cleaner and detergent bottles, shampoo bottles, cooking oil bottles, clear food packaging, wire jacketing, medical equipment, siding, windows, piping

Number 4 Plastics

LDPE (*low density polyethylene*)

Low density polyethylene, found in Squeezable bottles; bread, frozen food, dry cleaning and shopping bags; tote bags; clothing; furniture; carpe

Number 5 Plastics

PP (*polypropylene*)

Polypropylene, found in. Some yogurt containers, syrup bottles, ketchup bottles, caps, straws, medicine bottles

Number 6 Plastics

PS (*polystyrene*)

Polystyrene, found in: Disposable plates and cups, meat trays, egg cartons, carry-out containers, aspirin bottles, compact disc cases

Number 7 Plastics

Miscellaneous

Found in Three- and five-gallon water bottles, 'bullet-proof' materials, sunglasses, DVDs, iPod and computer cases, signs and displays, certain food containers, nylon

- A wide variety of plastic resins that don't fit into the previous categories are lumped into number 7. A few are even made from plants (polyactide) and are compostable. Polycarbonate is number 7, and is the hard plastic that has parents worried these days, after studies have shown it can leach potential hormone disruptors.

So, these are the different types of plastic, which are classified according to the use and chances of reprocessing. Among them, the number 1, 2 and 6 are commonly collected for recycling, but, 3, 4, 5 are not recycled on a regular manner. Plastic items without numbers too are not fit for recycling. So, you can reduce the use of plastic or else, opt for those in category 1, 2 and 6.

Fertilizers

(CSS 2001/ 2002 /2004 /2011)

What are fertilizers? What do you understand by the term NPK fertilizer? How does fertilization contribute to the pollution? 2002/2004

Fertilizers 2002 2004 2011

While nature can provide most nutrients to a limited degree, it takes years, or even decades for organisms in the soil to build up enough nutrients for a decent crop yield. One crop in virgin soil can mine many years' worth of naturally produced nutrients in a single growing season. When soils have been drained of all the nutrients needed, nature needs a little help. That's where fertilizers step in.

To make plants grow strong, healthy and fast, what you need to do is supply the 16 elements that the plants need in readily available, water-soluble forms. That is the goal of fertilizer.

Sixteen chemical elements are known to be important to a plant's growth and survival. The sixteen chemical elements are divided into two main groups: **Non-Mineral** *and* **Mineral.**

Non-Mineral Nutrients

The *Non-Mineral Nutrients* are *hydrogen* **(H)**, *oxygen* **(O)**, & *carbon* **(C).**

These nutrients are found in the air and water.

In a process called *photosynthesis*, plants use *energy from the sun* to change *carbon dioxide* (CO_2 - carbon and oxygen) and *water* (H_2O- hydrogen and oxygen) into starches and sugars. These starches and sugars are the plant's food.

Photosynthesis means "making things with light".

Since plants get carbon, hydrogen, and oxygen from the air and water, there is little farmers and gardeners can do to control how much of these nutrients a plant can use

Mineral Nutrients

The mineral nutrients are divided into two groups:

Macronutrients *and* **Micronutrients.**

Macronutrients

Macronutrients can be broken into two more groups:

Primary and Secondary Nutrients

The *primary nutrients* are nitrogen **(N)**, phosphorus **(P)**, *and* potassium **(K)**. These major nutrients usually are lacking from the soil first because plants use large amounts for their growth and survival.

The *secondary nutrients* are calcium **(Ca)**, magnesium **(Mg)**, *and* sulfur **(S)**. There are usually enough of these nutrients in the soil so fertilization is not always needed. Also, large amounts of Calcium and Magnesium are added when lime is applied to acidic soils. Sulfur is usually found in sufficient amounts from the slow decomposition of soil organic matter, an important reason for not throwing out grass clippings and leaves.

Micronutrients

"Micronutrients are to agriculture as vitamins are to the human diet." - Braun

Micronutrients are those elements essential for plant growth which are needed in very small (micro) quantities. These elements are sometimes called minor elements or trace elements, but use of the term micronutrient is encouraged by the American Society of Agronomy and the Soil Science Society of America. The micronutrients are boron **(B)**, copper **(Cu)**, iron **(Fe)**, chloride **(Cl)**, manganese **(Mn)**, molybdenum **(Mo)** and zinc **(Zn)**. Recycling organic matter such as grass clippings and tree leaves is an excellent way of providing micronutrients (as well as macronutrients) to growing plants.

NPK and Fertilizers

The three main nutrients that have been identified as absolutely necessary for plants are nitrogen (N), phosphorus (P) and potassium (K). These three are also known as macronutrients and are the source of the three numbers commonly found on organic fertilizer labels.

- **Nitrogen (N)** is responsible for above-ground vegetative growth of plants, and for overall size and vigor. It is probably best known for its ability to "green up" lawns. That's because nitrogen is a major component of chlorophyll, the green substance in plants responsible for photosynthesis. Nitrogen can be added to your soil through composted manure, blood meal, canola meal, and fish powder. Too much nitrogen and your plants will grow extremely fast, resulting in long, spindly, weak shoots with dark green leaves. Too little nitrogen and your plants will slow or even stop their growth, and have leaves turning yellow and dropping sooner than they should.
- **Phosphorus (P)** promotes healthy growth, strong roots, fruit and flower development and greater resistance to disease. Rock phosphate, bone meal and some guanos are sources of phosphorous. A phosphorus deficiency is recognized by dull green leaves and purplish stems. Plants are generally unhealthy, sometimes yellowing. Lack of blooming with lush green foliage may also indicated a lack of phosphorus.
- **Potassium (K)**, also known as potash, is essential for the development of strong plants. It helps plants to resist diseases and protects them from the cold. Because potassium plays a supporting role, it can be hard to spot deficiencies. Generally, leaves will show blue, yellow or purple tints with brown blotches or discoloration within or at the edges. Plants will lack growth and have small fruit and sickly blooms. Sources of potassium include greensand, sul-po-mag (sulfate of potash magnesia, quick release), and many liquid fertilizers

Organic *vs* Synthetic Fertilizers

Organic fertilizers are made from naturally occurring substances, and include by-products or waste remains of the animals. Dead plants and dead animal remains are also often used as fertilizers in organic farming. They are naturally chemical-rich and contain high amounts of nitrogen, phosphorus and potassium (NPK).

The main difference between a chemical and an organic fertilizer is that the former come out of a lab and the organic one comes from living beings. A chemical fertilizer is synthetically prepared to include the vital nutrients that are necessary for the plant's growth process. All of them contain the normal NPK requirement and any other nutrients as required.

Comparing the Two Fertilizer Types

Benefits of Organic Fertilizers

Production:

They are made by natural processes. Although they take time to make due to the nature of its 'ingredients', they prove to be much better when you produce them at a constant rate. Plus, you know exactly what's going into it so you can figure out if you want to add or substitute some things.

Effect on Biological Activity:

Chemical fertilizers kill the microorganisms in the soil. It is one of the advantages of organic fertilizers that they boost microbial activity in the soil. These microbes help in degenerating the complex compounds present in the organic fertilizers.

Effect on Soil:

Overuse of fertilizers is often a problem as excess nutrients are neither good for the overall composition of soil nor are they good for the plant. Organic fertilizers may also have a problem of overuse, but it is a slow nutrient releasing material, so the nutrients will anyway take some time to get absorbed.

Effect on Environment:

It is one of the greatest advantages of organic fertilizers that they are easily available in nature, in plenty and with almost no adverse effect on the environment. Chemical fertilizers on the other hand might have the problem of nitrogen components seeping into groundwater streams or otherwise into the nearest lake or river and causing pollution.

Price:

Organic fertilizers are much cheaper compared to their chemical counterparts as they are easily available in nature and only require packaging. Chemical fertilizers need extensive research and production work making them much more expensive.

Benefits of Chemical Fertilizers

Composition:

It is custom-made for your requirement. Now if your soil is rich in nitrogen and potassium, what you need is a fertilizer that will take care of the phosphorus deficiency. Chemical fertilizers will give you the option of using phosphorus-rich fertilizers.

Fertility:

While organic fertilizers have a low NPK ratio, the chemical ones enjoy a very high ratio of the same. So if you have a very unproductive soil, chemical fertilizers are what you need as they have an NPK ratio of nearly 60% while the most fertile of organic fertilizers can give only about 14%.

Release time:

Organic fertilizers may take more time to release the nutrients as they need some microbial activity to get them working. Chemical fertilizers get cracking instantly and release the essential nutrients into the soil.

It's now pretty obvious that using chemical fertilizers excessively will not only harm your plants, but the soil and the underground water reservoir as well. They can produce optimum results is used in monitored moderation. Organic fertilizers on the other hand, prove to be better in the long run, as long as your land isn't desperately low on one or more compounds. Thus we now know the advantages and disadvantages of each type of fertilizer. This will help us solve the old dilemma once and for all.

Impact *of* Fertilizers *on* Health *and* Environment

With the rapid increase in population globally, the demand of food and agricultural yield has been rising tremendously. This is the reason why statistics show that almost 40-60% of agricultural crops are grown with the use of different types of fertilizers. Not only this, more than

50% people feed on crops that are grown as a result of using synthetic fertilizers. On the other hand, there are organic fertilizers that consist of manures and animal wastes.

Environmental Dangers

Fertilizers are composed of elements that can be hazardous to the environment. For example, the common fertilizer ingredient phosphorus is dangerous when used near streams and lakes; when combined with fertilizer high in nitrogen, phosphorus causes eutrophication resulting in excessive algae growth that suffocates aquatic species. In addition, micronutrient fertilizers have been found to contain arsenic, cadmium and lead. Fertilizers derived from sewage waste may contain dioxins, which can cause further environmental risk.

Depletes the Quality of the Soil

The fact is that using too much of fertilizers in the soil can alter the fertility of the soil by increasing the acid levels in the soil. The level of soil pH varies from 0-14, wherein 0 is considered to be the most acidic and 14 being the most basic. 7 is considered to be neutral. The ideal soil pH varies from plant to plant and can be altered by bringing in some changes. Bottom line for using too much of fertilizers in the soil is that, though it may seem to work currently, there are high chances that you may not use it for plant yielding in the long run.

Alters the Biology of Water Bodies

When we use too much of fertilizers in the soil, it leads to eutrophication. Fertilizers contain substances like nitrates and phosphates that are flooded into lakes and oceans through rains and sewage. These substances prove to become toxic for the aquatic life, thereby, increasing the excessive growth of algae in the water bodies and decreasing the levels of oxygen. This leads to a toxic environment and leads to death of fish and other aquatic fauna and flora. Indirectly, it contributes to an imbalance in the food chain as the different kinds of fishes in the water bodies tend to be the main food source of various birds and animals in the environment. More than 50% of the lakes in the United States are eutrophic!

Affects on Human Health

The nitrogen and other chemicals present in the fertilizers can also affect the ground waters and waters that are used for the purpose of drinking! One of the most common result for this can be the development of blue baby syndrome which occurs in infants whose skin tissues are low in oxygen, which is why their skin appears to be blue or purplish in color. The use of lawn fertilizers and pesticides can cause health risks like cancer and chronic diseases in humans, especially in children.

Arsenic and lead are believed to cause cancer, and mercury, also found in some fertilizers, can result in developmental problems. Mercury, lead and cadmium are slow to break down in soil and thus result in prolonged exposure, making even low levels of these elements hazardous and increasing risk of birth defects, cancer and reproductive problems.

Climate Changes across the Globe

Fertilizers consists of substances and chemicals like methane, carbon dioxide, ammonia, and nitrogen, the emission of which has contributed to a great extent in the quantity of greenhouse gases present in the environment. This in turn is leading to global warming and weather changes. In fact, nitrous oxide, which is a byproduct of nitrogen, is the third most significant greenhouse gas, after carbon dioxide and methane.

Plant Hazards

Fertilizer can also be a hazard to the very plants it is supposed to be helping to grow and thrive. Use of mineral fertilizers over time decreases the numbers of naturally occurring bacteria

and fungi, as well as worms, found in soil -- a serious problem to plants, which depend on these organisms for proper development. Excessive buildup of fertilizer stresses plants and leaves them more susceptible to pests and disease. Liquid fertilizers, which are sprayed directly on plants, must be used with particular care because improper use can result in burned leaves.

Pesticides

(CSS 1990, 1995, 2000, 2001, 2002, 2003, 2010, 2012, 2013)

Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (*weeds*). Pesticides are used in public health to kill vectors of disease, such as mosquitoes, and in agriculture, to kill pests that damage crops. By their nature, pesticides are potentially toxic to other organisms, including humans, and need to be used safely and disposed off properly.

The term pesticide applies to a number of substances which are used to manage pests such as insects, weeds, fungi, bacteria and viruses. Pesticides are commonly associated with chemicals that exterminate, kill or destroy a pest. In fact the word ends with "cide", which means "kill". While many pesticides do in fact kill a pest not all are used for that purpose. *For example*, certain pesticides, known as insect repellents, repel insects but do not actually kill them. Other types of pesticides, such as plant desiccants, are used to aid in the harvesting of the plants to which they are applied. It is important to understand that the term pesticide applies to a broad group of chemicals and substances not just bug killers (*insecticide*) and weed killers (*herbicides*).

In general, a pesticide could be defined in the following manner:

1. Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, fungi, bacteria, weeds, or other forms of plant or animal life, bacterium, or viruses, except viruses living on or in living man or other animals or
2. Any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Classification of Pesticides Based on Origin and Pest Control

Classification Based on their Origin

There are two types – chemical pesticides and bio pesticides.

Chemical pesticides *are further divided into four types based on their origin –*

1. **Organophosphate pesticides** - These are the chemical substances which are produced due to reaction between phosphoric acid and alcohols. This affects the nervous system by inhibiting the action of enzyme acetyl cholinesterase (AChE). This causes irreversible blockage leading to accumulation of the enzyme which results in overstimulation of muscles. These mainly include insecticides, nerve gases, herbicides, etc.
2. **Carbonate** - These are esters of carbamic acids. The mode of action is inhibiting acetyl cholinesterase similar to that of the organophosphates but the bond formed for inhibition is less durable and thus reversible. These also include mainly of insecticides.
3. **Organ chlorine pesticides**- These are the derived from chlorinated hydrocarbons. These are endocrine disrupting agents which effect on the hormonal systems of the body, act as duplicates of the normal hormones and thus causing adverse health problems. They remain in environment for a long time by breaking down slowly and accumulating in the fat tissues of animals. A well-known example is DDT (dichloro diphenyl trichloroethane).
4. **Parathyroid pesticides**- These are potent nuero poisons, endocrine disruptors and cause paralysis. Pyrethroids are synthetic version of pyrethrin a natural insecticide. They have

similar chemical structure and similar mode of action as of pyrethrin which is obta from chrysanthemum. These are derivatives of ketoalcoholic esters of chrysanthemic pyrethroic acids and are more stable in sunlight than pyrethrins. These are most popu insecticides as they can easily pass through the exoskeleton of the insect. Few examp are- deltamethrin, cypermethrin, etc.

Bio pesticides:

These are naturally occurring materials or derived naturally from living organisms their metabolites, like bacteria, fungi, plants, etc. *These are classified into three major grou*

1. **Microbial pesticides-** This has microorganisms acting as pest controllers like bacte fungi or viruses. Each of it contains specific target. Widely used are strains of Bacil Thuringenesis or Bt and its subspecies. The mode of action generally is producing protein that binds to the larval gut receptor which starves the larvae.
2. **Biochemical pesticides-** They are naturally occurring, nontoxic pest controllers. They include pheromones, natural plant and insect regulators, enzymes, bio repellents attractants.
3. **Plant incorporated protectants** (PIPs) - These substances are produced by plan naturally but the gene necessary for production of pesticide is introduced into the plan through genetic engineering. The substance produced by the plant and the genet material introduced are together defined as plant incorporated protectants (PIPs).

Classification Based *on their* Pests *they* Control-

1. **Insecticides-** These act especially on insects.
2. **Algaecides-** control or kill growth of algae.
3. **Herbicides** – controls or kills weeds.
4. **Bactericides** - acts against bacteria.
5. **Fungicides-** acts against fungi.
6. **Rodenticides-** kills or prevents rodents i.e. rats or mice.
7. **Larvicides** – inhibits growth of larvae.
8. **Repellents** – they tend to repel pests by its taste or smell.
9. **Desiccants-** they act on plants by drying their tissues.
10. **Ovicides** – they inhibits the growth of eggs of insects and mites.
11. **Virucides-** acts against viruses.
12. **Molluscicides** – they inhibit or kill mollusc's i.e snail's usually disturbing growth of plants or crops.
13. **Acaricides** – they kill arachnids like mites.
14. **Nematicides** – they are tend to kill nematodes that act as parasites of plants.
15. **Avicides** – these are used to kill birds.
16. **Moth balls-** these are used to stop any damage to cloths by moth larvae or molds.
17. **Lampricides** – these are designed to target larvae of lampreys which are jawless fish lik vertebrates in the river.
18. **Piscicides** – they are substances that act against fishes.

Though pesticides are designed to kill or inhibit organisms that cause damage to the crop or animals, they have harmful effects on other organisms that must not be effected and tend t pollute the environment. If used in high quantities they can be lethal sometimes. Biopesticides ar used instead of chemical pesticides as the negative effects are low compared to chemica pesticides.

Insecticide Classification Based *on* Mode of Action

Insecticides kill insects. However, how an insecticide works is called its mode of action. A complete understanding of the mode of action of an insecticide requires knowledge of how it affects a specific target site within an organism. The target site is usually a critical protein or enzyme in the insect, but some insecticides affect broader targets

For example, silica aerogels affect the entire lipid layer on the insect cuticle. Although most insecticides have multiple biological effects, toxicity is usually attributed to a single major effect.

Insecticides can be classified according to their mode of entry into the insect as

1) Stomach poisons

The pesticide enters the body of pests via their mouthpart and digestive system and causes death by poisoning. Pesticides that function in this way are known as stomach poison.

2) Contact poisons

The pesticide enters the body of pests via their epidermis upon contact and causes death by poisoning. Pesticides that function in this way are known as contact poison.

3) Fumigants.

The pesticide in gas form enters the body of pests via their respiration system and causes death by poisoning.

However, many insecticides belong to more than one category when grouped in this way, limiting its usefulness. Another way insecticides can be classified is by their mode of action. Most insecticides affect one of five biological systems in insects. *These include*

1. The nervous system,
2. The production of energy,
3. The production of cuticle,
4. The endocrine system
5. Water balance. This method of classification is preferred among scientists.

Impact Food Production Using Pesticide

Modern agriculture is a combination of both and human intervention is necessary, whether it be pulling out weeds by hand, use of pesticides or genetic engineering. Control methods evolve over time as knowledge and techniques improve. This includes the development of chemical means of control which become very important because of a number of advantages. *For example:*

1. **Cost Effectiveness.** Farm chemicals are an economical way of controlling pests. They require low labour input and allow large areas to be treated quickly and efficiently. It has been conservatively estimated that for every dollar a farmer spends on farm chemicals he receives $4 return (Anon, 1990a). Production per labour unit has increased while production costs and energy inputs are lower.
2. **Timeliness and Flexibility.** A suitable farm chemical is available for most pest problems with variations in activity, selectivity and persistence. The best product can be chosen for the situation. This allows more flexibility in management options and better timeliness of pest control.
3. **Quality, Quantity and Price of Produce.** Farm chemicals ensure a plentiful supply and variety of high quality, wholesome food at a reasonable price. Modern society demands nutritious food free from harmful organisms and blemishes. Ornamental horticulture also requires unblemished and pest-free plants and flowers. This would be very difficult

without farm chemicals.

4. **Prevention of Problems.** Farm chemicals are frequently used to prevent pest problems from occurring, e.g. preventing weeds in gardens and lawns; treatment of export and import produce to prevent the spread of pests; treatment of stored products to prevent pest attack and destruction during storage.
5. **Protection of Pets and Humans.** Without farm chemicals the treatment of spiders, cockroaches, etc in houses; fleas on pets, etc. would be most difficult.
6. **Protection of the Environment.** If no farm chemicals were available to control environmental pests like noxious weeds, feral animals, etc. our environment would suffer very badly. Using herbicides to control crop weeds reduces the need for cultivation, thus reducing land degradation.

Hazards of Pesticides

In today's modern society, it is common to use chemical pesticides to control insect pests. In fact, their use throughout the world has increased by 50% over the last 30 years, and 2.5 million tons of commercial pesticides are now applied annually. The problem is, as our reliance on chemical pesticides increases (*along with their cost*), their effectiveness is declining. Crop yields lost to insects are greater now than they have ever been, even with increased toxicity.

1. **Pesticides create secondary pest problems.** Chemical insecticides are rarely selective and kill a large number of insects, including the good ones. The environment created by indiscriminate insecticide use often allows other insects — not the initial pest but different insects seeking out food — to rapidly increase in number because no natural enemies (beneficial insects) remain to prevent the population explosion. In some instances, secondary pests cause greater damage than the insects that were initially the problem **Note:** *Less than 1% of the world's insects are considered pests. The other 99% play a pivotal role in our food chain and many are indispensable.*
2. **Pesticides invoke resistance.** Insect pests have an uncanny ability to develop resistance to conventional insecticides. Currently, there are more than 500 insect pest and mite species that have shown resistance. In fact, some of the most destructive pests found in the garden cannot be controlled with today's chemicals.
3. **The economics of pesticide use.** The combination of secondary pest outbreaks, insect resistance, government regulations, and legal battles over safety and the environment have caused the cost of chemical insecticides to rise dramatically.
4. **Pesticides and Human Health:** Pesticides have been linked to a wide range of human health hazards, ranging from short-term impacts such as headaches and nausea to chronic impacts like cancer, reproductive harm, and endocrine disruption Acute dangers - such as nerve, skin, and eye irritation and damage, headaches, dizziness, nausea, fatigue, and systemic poisoning - can sometimes be dramatic, and even occasionally fatal. Chronic health effects may occur years after even minimal exposure to pesticides in the environment, or result from the pesticide residues which we ingest through our food and water. Pesticides can cause many types of cancer in humans. Some of the most prevalent forms include leukemia, non-Hodgkins lymphoma, brain, bone, breast, ovarian, prostate, testicular and liver cancers.
5. **Pesticides and the Environment:** Pesticides are toxic to living organisms. Some can accumulate in water systems, pollute the air, and in some cases have other dramatic environmental effects. Scientists are discovering new threats to the environment that are equally disturbing. Pesticide use can damage agricultural land by harming beneficial insect species, soil microorganisms, and worms which naturally limit pest populations and maintain soil health; Weakening plant root systems and immune systems; Reducing concentrations of essential plant nutrients in the soil such nitrogen and phosphorous.

6. **Reduction of beneficial species**: Animals which interact with the targeted pest can also be affected by he chemical application. The reduction in these other organisms can result in changes in the biodiversity of an area and affect natural biological balances.
7. **Drift of sprays and vapour**: Pesticides can affect other areas during application and can cause severe problems in different crops, livestock, waterways and the general environment. Wildlife and fish are the most affected. Taking special note of weather conditions can reduce drift.
8. **Residues in food**: There is the possibility of pesticides in human food, either by direct application onto the food, or by bio-magnification along the food line. Not all levels are undesirable but unnecessary and dangerous levels must be avoided through good agricultural practice.
9. **Ground water contamination**: Chemicals can reach underground aquifers if there is persistent product use in agricultural areas.
10. **Poisoning hazards**: Pesticide operators can risk poisoning through excessive exposure if safe handling procedure are not followed and protective clothing is not worn. Poisoning risks depend on dose, toxicity, duration of exposure and sensitivity.

Pesticides Safety

1. **Cultural Control:** Involves manipulation of the environment to favor beneficial insects, and/or inhibit pests. Changes can include adjusting soil pH, watering practices, amount of sunlight, or selecting pest-resistant plants.
2. **Mechanical Control:** Includes a wide variety of tools that remove, trap or exclude garden pests. These methods include copper tape for slugs, yellow sticky traps for aphids, or even hand-picking.
3. **Beneficial Insects:** Used in this country since the late 1880's, these predatory and parasitic insects attack and destroy only insects; they are harmless to people, plants and pets.
4. **Biological Pesticides:** Usually pest specific, these are either living organisms (parasites, predators, and pathogens) or are the toxins produced by them. Biological pesticides have very little or no effect on beneficial insects, and are safe for the environment.
5. **Soaps, Oils and Abrasives:** These controls are broad-based in their actions and include products that dehydrate or smother pest insects (diatomaceous earth, insecticidal soap, horticultural oil). They are generally considered "natural" and degrade quickly in the environment. However, they are NOT selective. Take precautions when using around beneficial insects.
6. **Botanical Insecticides:** Derived from plants, these organic pesticides provide a quick "knock down" to a large number of garden pests. They are powerful insecticides, but non-selective and will harm beneficial insects. A major advantage of botanical insecticides: they usually biodegrade much more quickly than their chemical cousins.
7. **Protect desirable plants**, insects, soil, and the water table from exposure and contamination. Avoid pesticide drift and runoff.
8. **Do not use pesticide measuring cups** and containers for any other purpose. Buy

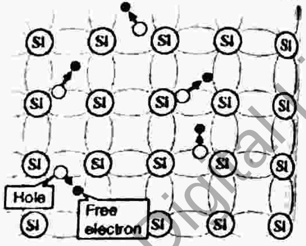
measuring cups and containers that are only for pesticide use.

9. **Dispose of pesticides** and pesticide containers as directed by the label.
10. **Reduce your exposure to chemicals** by wearing and using the proper clothing and equipment. Be careful when mixing chemicals!

Semiconductor

(CSS 1990, 1998, 2000, 2008, 2011, 2012, 2013/Fsd Re-exam)

The magic word semiconductor is composed of two words-**Semi** and **Conductor**. Semi means not completely while conductor mean something, which can conduct electricity. Everybody is familiar with "Electricity". It is present everywhere; it runs many appliances in your home and outside the home like TV, Bulb, Freeze, and Microwave Oven etc. In simple terms, the current must past through wires so that the electricity can reach all these appliances. So a conductor is nothing but a material having ability to conduct this electricity. Semiconductors conduct electricity to some extent, less than the conductors, how much do you think? Well, it depends on the type of material or it's mixture and size. A semiconductor is a material that has intermediate conductivity between a conductor and an insulator. It means that it has unique physical properties somewhere in between a conductor like aluminum and an insulator like glass. In a process called doping, small amounts of impurities are added to pure semiconductors causing large changes in the conductivity of the material. Examples include silicon, the basic material used in the integrated circuit, and germanium, the semiconductor used for the first transistors.



Examples of semiconductors include chemical elements and compounds such as silicon, germanium, and gallium arsenide. The conductivity of a semiconductor increases with temperature, light, or the addition of impurities because these increase the number of conductive valence electrons of the semiconductor. Valence or outer electrons are the carriers of the electrical current.

In an intrinsic semiconductor such as silicon, the valence electrons of an atom are paired and shared with other atoms, making covalent bonds that hold the crystal together. Under such circumstances, these valence electrons are not free to move around as electrical current. Temperature or light excites the valence electrons out of these bonds, freeing them to conduct current. The vacant positions left behind by the freed electrons, also known as *holes*, can move around as well, contributing to the flow of electricity. The energy needed to excite the electron and hole is known as the *energy gap*.

Types of Semiconductors

Semiconductors are mainly classified into two categories:

1. Intrinsic
2. Extrinsic.

- **An intrinsic semiconductor** material is chemically very pure and possesses poor conductivity. It has equal numbers of negative carriers (electrons) and positive carriers (holes).
- *Where as* **an extrinsic semiconductor** is an improved intrinsic semiconductor with a small amount of impurities added by a process, known as **doping**, which alters the electrical properties of the semiconductor and improves its conductivity. Introducing impurities into the semiconductor materials (doping process) can control their conductivity.

Doping process produces two groups of semiconductors:

1. The negative charge conductor (n-type)
2. The positive charge conductor (p-type).

Semiconductors are available as either elements or compounds. Silicon and Germanium are the most common elemental semiconductors. Compound Semiconductors include InSb, InAs, GaP, GaSb, GaAs, SiC, GaN. Si and Ge both have a crystalline structure called the diamond lattice. That is, each atom has its four nearest neighbors at the corners of a regular tetrahedron with the atom itself being at the center. In addition to the pure element semiconductors, many alloys and compounds are semiconductors. The advantage of compound semiconductor is that they provide the device engineer with a wide range of energy gaps and mobilities, so that materials are available with properties that meet specific requirements. Some of these semiconductors are therefore called wide band gap semiconductors.

How Do Semiconductor Work?

Most of the semiconductor devices and chips are created with silicon. The commonly heard expressions like "Silicon Valley" and the "Silicon Economy" come from this fact. Carbon, silicon and germanium have a unique property in their electron structure -- each has four electrons in its outer orbital. This allows them to form nice crystals. The four electrons form perfect covalent bonds with four neighboring atoms, creating a lattice. In carbon, we know the crystalline form as diamond. In silicon, the crystalline form is a silvery, metallic-looking substance. Metals tend to be good conductors of electricity because they usually have "free electrons" that can move easily between atoms, and electricity involves the flow of electrons. While silicon crystals look metallic, they are not, in fact, metals. All of the outer electrons in a silicon crystal are involved in perfect covalent bonds, so they can't move around.

A pure silicon crystal is nearly an insulator -- very little electricity will flow through it. You can change the behavior of silicon and turn it into a conductor by doping it. In doping, you mix a small amount of an impurity into the silicon crystal. A minute amount of either N-type or P-type doping turns a silicon crystal from a good insulator into a viable (but not great) conductor -- hence the name *"semiconductor."*

However electrons are not the only players in the "conduction game"! Another particle plays a major role in conduction in semiconductors. *What is this particle?* That is also what happens when an electron in a semiconductor jumps from the valence band to the conduction band. It is called a *hole*. Some electrons and holes play an important role in electrical conduction in semiconductors:

- o These electrons are the ones that jumped in the conduction band
- o These holes are the ones that are created in the valence band

Electrons have a negative charge. Holes have a positive charge. Electrons and holes are not static; they can move. Holes move more slowly than electrons. When electrons move in one direction, holes move in the opposite direction. This is like cars parked along a street. If one car moves to an empty slot, the empty slot moves the other way. The cars move to the right, the empty slot to the left. A solitary electron in the presence of a solitary hole will recombine. Only electrons and holes which are free, and hence have not recombined, play a role in electric conduction.

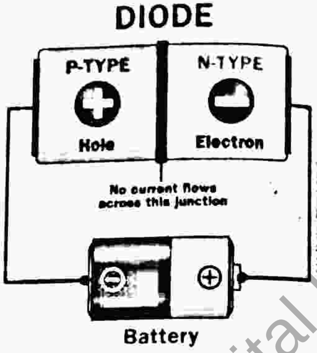
Shockley, Bardeen and Brattain, the men behind the transistor, were awarded the 1956 Nobel Prize in Physics. With the invention of the transistor, the extraordinary usefulness of semiconductors was recognized.

Diode

A *diode* is the simplest possible semiconductor device. A diode allows current to flow in one direction but not the other.

When you put N-type and P-type silicon together as shown in this diagram, you get a very interesting phenomenon that gives a diode its unique properties.

Even though N-type silicon by itself is a conductor, and P-type silicon by itself is also a conductor, the combination shown in the diagram does not conduct any electricity. The negative electrons in the N-type silicon get attracted to the positive terminal of the battery. The positive holes in the P-type silicon get attracted to the negative terminal of the battery. No current flows across the junction because the holes and the electrons are each moving in the wrong direction.



If you *flip the battery around*, the diode conducts electricity just fine. The free electrons in the N-type silicon are repelled by the negative terminal of the battery. The holes in the P-type silicon are repelled by the positive terminal. At the *junction* between the N-type and P-type silicon, holes and free electrons meet. The electrons fill the holes. Those holes and free electrons cease to exist, and new holes and electrons spring up to take their place. The effect is that **current flows** through the junction.

Difference between. Conductors, Semiconductors *and* Insulators

(CSS 2011/2012/2013 Fsd Re-Exam)

Solid-state materials can be classified into three groups: insulators, semiconductors and conductors.

- **Insulators** are materials having an electrical conductivity $\sigma\cdot\ 10^{\ 8} S/cm$
  (*Like diamond: 10-14S/cm*)
- **Semiconductors** have a conductivity $10^{\ 8} S/cm\cdot\ \sigma\cdot\ 10^{3} S/cm$
  (For *silicon it can range from 10-5S/cm to 103S/cm*)
- **Conductors** are materials with high conductivities $10^{3} S/cm\cdot\ \sigma$
  (*Like silver: 106S/cm.*)

The electrical properties of a given material depend on the electronic populations of the different allowed bands. Electrical conduction is the result of electron motion within each band. When an electric field is applied to the material, electrons start to move in the direction opposed

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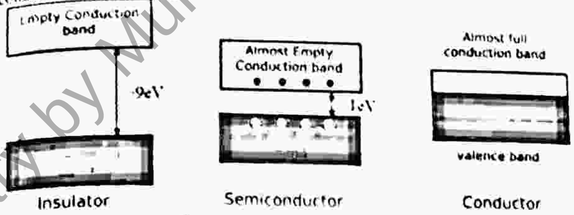
to the direction of the electric field. An empty energy band (in which there is no free electron) does not of course participate in the formation of an electric current. It is also the case for a fully occupied band. Indeed, an electron can move provided that, whenever it leaves its site, it can find some free space elsewhere (another available site within its energy band, called a "hole"), where it can go. A material with fully occupied or empty energy bands is then an insulator. This is the case when the gap energy exceeds ~9eV, because for such gaps, the thermal energy at 300K (~25 meV) is clearly insufficient to allow electrons from the valence band to be promoted to the conduction band. In this case the valence band (and all bands of lower energy) is fully occupied, and the conduction band is empty.



Representation of energy bands

A semiconductor is primarily an insulator at 0K. However, since the energy gap is lower compared to insulators (~1eV), the valence band is slightly thermally populated at room temperature, whereas the conduction band is slightly depopulated. Since electrical conduction is directly connected to the number of electrons in the "almost empty" conduction band and to the number of holes in the "almost fully occupied" valence band, it can be expected that the electrical conductivity of such an intrinsic semiconductor will be very small.

For a conductor, conduction bands and valence bands are not separated and there is therefore no energy gap. The conduction band is then partially occupied (*even at low temperatures*), resulting in a "high" electrical conductivity.

Conductors Insulators and Electron Flow

The electrons of different types of atoms have different degrees of freedom to move around. With some types of materials, such as metals, the outermost electrons in the atoms are so loosely bound that they chaotically move in the space between the atoms of that material by nothing more than the influence of room-temperature heat energy. Because these virtually unbound electrons are free to leave their respective atoms and float around in the space between adjacent atoms, they are often called *free electrons*.

In other types of materials such as glass, the atoms' electrons have very little freedom to move around. While external forces such as physical rubbing can force some of these electrons to leave their respective atoms and transfer to the atoms of another material, they do not move between atoms within that material very easily.

This relative mobility of electrons within a material is known as electric *conductivity*. Conductivity is determined by the types of atoms in a material (the number of protons in each atom's nucleus, determining its chemical identity) and how the atoms are linked together with one another. Materials with high electron mobility (many free electrons) are called *conductors*, while materials with low electron mobility (few or no free electrons) are called *insulators*.

Here are a few common examples of conductors and insulators:

Conductors:

Silver	Copper	Gold
Aluminum	Iron	Steel
Brass	Bronze	Mercury
Graphite	Dirty water	Concrete

Insulators:

Glass	Rubber	Oil
Asphalt	Fiberglass	Porcelain
Ceramic	Quartz	(*Dry*) cotton
(*Dry*) paper	(*Dry*) wood	Plastic
Air	Diamond	Pure water

It must be understood that not all conductive materials have the same level of conductivity, and not all insulators are equally resistant to electron motion. Electrical conductivity is analogous to the transparency of certain materials to light: materials that easily "conduct" light are called "transparent," while those that don't are called "opaque." However, not all transparent materials are equally conductive to light. Window glass is better than most plastics, and certainly better than "clear" fiberglass. So it is with electrical conductors, some being better than others.

For instance, silver is the best conductor in the "conductors" list, offering easier passage for electrons than any other material cited. Dirty water and concrete are also listed as conductors, but these materials are substantially less conductive than any metal.

Biofuel

Biofuel- is a wide range of fuels which are in some way derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Biofuels are gaining increased public and scientific attention, driven by factors such as oil price spikes and the need for increased energy security. Biofuel is a gas or liquid fuel made from plant material (biomass). Includes wood, wood waste, wood liquors, peat, railroad ties, wood sludge, spent sulfite liquors, agricultural waste, straw, tires, fish oils, tall oil, sludge waste, waste alcohol, municipal solid waste, landfill gases, other waste, and ethanol blended into motor gasoline Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using trans esterification and is the most common biofuel in Europe. Pakistan hopes to build anaerobic digesters in rural areas. for the production of Biogas to supplement gas yields. Pakistan State Oil on July 10, 2009 launched Pakistan's first environment-friendly fuel - E10 Gasoline - in Karachi, Lahore and Islamabad

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Biofuel

Q: Define the term "Bio Fuel' How is it helpful to promote clean energy (CSS 2018)

Introduction

Biofuel is fuel produced from renewable biomass material, commonly used as an alternative, cleaner fuel source to burning fossil fuels. Biofuels are low in carbon intensity so they don't directly affect global warming in fact, it is suggested that biofuel formulations can remove materials like logging waste and cooking oil from the waste stream. the world's largest producer of biodiesel accounting for 53% of production worldwide.

Types of Biofuels

The following are the current types of biofuels available:

- **Vegetable oil** is used in several old diesel engines that have indirect injection systems. This oil is also used to create biodiesel, which when mixed with conventional diesel fuel is compatible for most diesel engines. Used vegetable oil is converted into biodiesel. Sometimes, water and particulates are separated from the used vegetable oil and then this is used as a fuel.
- **Biodiesel** is a famous biofuel in Europe. Its composition is just like mineral diesel. When biodiesel is mixed with mineral diesel, the mixture can be used in any diesel engine. It is observed that in several nations, the diesel engines under warranty are converted to 100% biodiesel use. It has also been proved that most people can run their vehicles on biodiesel without any problem. A large number of vehicle manufacturers recommend the use of 15% biodiesel mixed with mineral diesel. In Europe, a 5% biodiesel blend is generally used at gas stations.
- **Bioalcohols** are biologically produced alcohols. Common among these are ethanol and rare among these are propanol and butanol. Biobutanol can be used directly in a gasoline engine and hence is considered a direct replacement for gasoline. The butanol can be burned straight in the existing gasoline engines without any alteration to the engine or car. It is also claimed that this butanol produces more energy. Also, butanol has a less corrosive effect and is less soluble in water than ethanol.
- **Ethanol fuel** is the most commonly used biofuel in the world and particularly in Brazil. Ethanol can be put to use in petrol engines as a substitute for gasoline. Also, it can be mixed with gasoline in any ratio. The contemporary automobile petrol engines can work on mixtures of gasoline and ethanol that have 15% bioethanol. This mixture of gasoline and ethanol has more quantity of octane. This indicates that the engine would burn hotter and more efficiently. In high altitude spots, the mixture of gasoline and ethanol is used as a winter oxidizer and thereby atmospheric pollution is decreased.
- **Biogas** is created when organic material is anaerobically digested by anaerobes. During production, there is a solid byproduct called digestate. This can be used as a biofuel or fertilizer. Biogas consists of methane. Landfill gas is created in landfills due to natural anaerobic digestion and is a less clean form of biogas. Dried manure, charcoal and wood are examples of Solid biofuels.

The combined processes of gasification, combustion and pyrolyis gives rise to Syngas which is a biofuel. This syngas can be directly burned in internal combustion engines. Syngas can be used to create hydrogen and methanol. By using the Fischer-Tropsch process, it can be transformed to a synthetic petroleum substitute.

First Generation: Made from seeds, grains, vegetable oil, animal fats, sugars, starch.

- **Biodiesel:** Produced from oils or fats using trans esterification which results in a liquid similar to diesel. Can be used in any diesel engine.
- **Bioalcohol:** Produced through the actions of microorganisms and enzymes through fermentation of sugars, straches, and cellulose.
- **Biogas:** Produced by anaerobic digestion of organic matter using anaerobes. Uses bio waste or energy crops as a process material.
- **Syngas:** Produced through a combined process of pyrolysis, combustion, and gasification. Biofuel is converted to carbon monoxide and energy using pyrolysis. Then a small amount of oxygen is introduced to help with combustion. After that gasification further converts the organic material to hydrogen and more carbon monoxide. The end product is a gas mixture which is more efficient than direct combustion.
- **Solids:** Burned directly in stoves or steam engines. Simple example being firewood burned to cook over.

Second Generation: Made from non-food crops, waste biomass.

The main idea behind second generation biofuels is to avoid crops that are consumed by humans. For example, poplar or inedible waste products like citrus peels or sawdust.

Third Generation: Made from algae.

Third generation biofuel is entirely focused on algae. Algae produces 30 times more energy per acre than crops like soybeans. The drawback to this is that algal oil is hard to extract but processes are improving.

Fourth Generation: Genetically engineering organisms to produce fuels.

Producing fuel directly from carbon dioxide and conversion of biodiesel into gasoline using genetically engineered organisms are both examples of fourth generation biofuels.

Advantages of Biofuels

1) **Cost Benefit:** As of now, biofuels cost the same in the market as gasoline does. However, the overall cost benefit of using them is much higher. They are cleaner fuels, which means they produce fewer emissions on burning. Biofuels are adaptable to current engine designs and perform very well in most conditions. This keeps the engine running for longer, requires less maintenance and brings down overall pollution check costs. With the increased demand of biofuels, they have a potential of becoming cheaper in future as well. So, the use of biofuels will be less of a drain on the wallet.
2) **Easy To Source:** Gasoline is refined from crude oil, which happens to be a non-renewable resource. Although current reservoirs of gas will sustain for many years, they will end sometime in near future. Biofuels are made from many different sources such as manure, waste from crops and plants grown specifically for the fuel.
3) **Renewable:** Most of the fossil fuels will expire and end up in smoke one day. Since most of the sources like manure, corn, switchgrass, soyabeans, waste from crops and plants are renewable and are not likely to run out any time soon, making the use of biofuels efficient in nature. These crops can be replanted again and again.
4) **Reduce Greenhouse Gases:** Fossil fuels, when burnt, produce large amount of greenhouse gases i.e. carbon dioxide in the atmosphere. These greenhouse gases trap sunlight and cause planet to warm. The burning of coal and oil increases the temperature and causes global warming. To reduce the impact of greenhouse gases, people around the world are using biofuels. Studies suggests that biofuels reduces greenhouse gases up to 65 percent.

5) **Economic Security:** Not every country has large reserves of crude oil. For them, having to import the oil puts a huge dent in the economy. If more people start shifting towards biofuels, a country can reduce its dependence on fossil fuels. More jobs will be created with a growing biofuel industry, which will keep our economy secure.
6) **Reduce Dependence on Foreign Oil:** While locally grown crops has reduce the nation's dependence on fossil fuels, many experts believe that it will take a long time to solve our energy needs. As prices of crude oil is touching sky high, we need some more alternative energy solutions to reduce our dependence on fossil fuels.
7) **Lower Levels of Pollution:** Since biofuels can be made from renewable resources, they cause less pollution to the planet. However, that is not the only reason why the use of biofuels is being encouraged. They release lower levels of carbon dioxide and other emissions when burnt. Although the production of biofuels creates carbon dioxide as a byproduct, it is frequently used to grow the plants that will be converted into the fuel. This allows it to become something close to a self sustaining system.

Disadvantages of Biofuels

1) **High Cost of Production:** Even with all the benefits associated with biofuels, they are quite expensive to produce in the current market. As of now, the interest and capital investment being put into biofuel production is fairly low but it can match demand. If the demand increases, then increasing the supply will be a long term operation, which will be quite expensive. Such a disadvantage is still preventing the use of biofuels from becoming more popular.
2) **Monoculture:** Monoculture refers to practice of producing same crops year after year, rather than producing various crops through a farmer's fields over time. While, this might be economically attractive for farmers but growing same crop every year may deprive the soil of nutrients that are put back into the soil through crop rotation.
3) **Use of Fertilizers:** Biofuels are produced from crops and these crops need fertilizers to grow better. The downside of using fertilizers is that they can have harmful effects on surrounding environment and may cause water pollution. Fertilizers contain nitrogen and phosphorus. They can be washed away from soil to nearby lake, river or pond.
4) **Shortage of Food:** Biofuels are extracted from plants and crops that have high levels of sugar in them. However, most of these crops are also used as food crops. Even though waste material from plants can be used as raw material, the requirement for such food crops will still exist. It will take up agricultural space from other crops, which can create a number of problems. Even if it does not cause an acute shortage of food, it will definitely put pressure on the current growth of crops. One major worry being faced by people is that the growing use of biofuels may just mean a rise in food prices as well.
5) **Industrial Pollution:** The carbon footprint of biofuels is less than the traditional forms of fuel when burnt. However, the process with which they are produced makes up for that. Production is largely dependent on lots of water and oil. Large scale industries meant for churning out biofuel are known to emit large amounts of emissions and cause small scale water pollution as well. Unless more efficient means of production are put into place, the overall carbon emission does not get a very big dent in it.
6) **Water Use:** Large quantities of water are required to irrigate the biofuel crops and it may

impose strain on local and regional water resources, if not managed wisely. In order produce corn based ethanol to meet local demand for biofuels, massive quantities water are used that could put unsustainable pressure on local water resources.

7) **Future Rise in Price:** Current technology being employed for the production of biof is not as efficient as it should be. Scientists are engaged in developing better means which we can extract this fuel. However, the cost of research and future installa means that the price of biofuels will see a significant spike. As of now, the prices comparable with gasoline and are still feasible. Constantly rising prices may make the of biofuels as harsh on the economy as the rising gas prices are doing right now.

Biological Sciences

Biology is a natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy From molecular biology to ecosystem ecology, biology is a vast subject providing a wide range of potential subjects to study Biologists study a wide range of environmental problems, from climate change to food security, disease epidemiology, or biodiversity conservation, with the study and manipulation of biological systems fundamental to our survival and development as a species.

Sub disciplines of biology are defined by the scale at which organisms are studied, the kinds of organisms studied, and the methods used to study them: biochemistry examines the rudimentary chemistry of life; molecular biology studies the complex interactions among biological molecules; botany studies the biology of plants; cellular biology examines the basic building block of all life, the cell; physiology examines the physical and chemical functions of tissues, organs, and organ systems of an organism; evolutionary biology examines the processes that produced the diversity of life; and ecology examines how organisms interact in their environment.

Biology is the study of life. Since life is such a broad topic, scientists break it down into several different organizations of biology to make it easier to study. These levels start from the smallest unit of life and work up to the largest and most broad category. Some scientists argue about how many levels there are, but most scientists agree that there are at least 10 levels of organization in biology.

Levels of Biological Organization

1. **Cell:** the smallest unit of life that is able to carry out all the functions of living things
2. **Molecules:** consists of different atoms. For example, DNA, within DNA there are oxygen atoms and different proteins
3. **Tissue:** Tissue is made of cells that work together to perform a certain task. Muscle tissue, for example, works together to move joints within the body
4. **Organ System** consists of different organs that work together for a specific function
5. **Organism:** An organism is a recognizable, self-contained individual. Most organisms are multi-cellular organisms and comprise organs and organ systems. A human being is an example of an organism.
6. **Population:** A population is a group of multiple organisms of the same species within a specific area. For example, a pride of lions in Kenya, Africa, is a population.
7. **Community:** A community consists of all the different species within a certain area. The population of lions in Kenya, plus the populations of gazelles, giraffes, elephants, dung beetles, and all other species in that area, add up to a community
8. **Ecosystem:** An ecosystem is made up of all the communities in a certain area, as well as

all the non-living, physical components of the environment. Rocks, water and dirt are a part of an ecosystem.

9. **Biosphere**: The biosphere is all of the ecosystems on Earth added together. Every animal, plant, bacteria, rock, and molecule is a part of the Earth's biosphere.

Cell

Q: Describe the 'Cell Structure'. Write down at least three difference between an animal cell and plant cell.

(CSS-2018)

The **cell** is the basic structural, functional and biological unit of all known living organisms. Cells are the smallest unit of life that is classified as a living thing, and are often called the "building blocks of life".

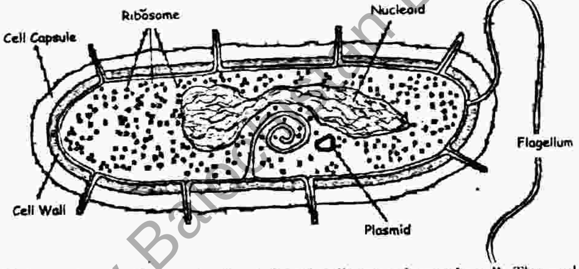
The cell was discovered by Robert Hooke in 1665. Cells emerged on Earth at least 3.5 billion years ago. The word *cell* comes from the Latin *cella*, meaning "small room". It was coined by Robert Hooke in his book *Micrographia* (1665), in which he compared the cork cells he saw through his microscope to the small rooms monks lived in.

Cells in humans and animals vary greatly in size. The smallest cells in the human body are sperm cells and the granule cell of the cerebellum. Some neurons, or nerve cells, may grow as long as several feet long and extend from the limbs to the spinal cord to the brain.

What are the different types of Cells?

All cells in living things can be classified in one of two basic cell types: prokaryotic and eukaryotic.

- **Prokaryotic cells** Prokaryotic cells are less organized and less dynamic than eukaryotic cells. Prokaryotes lack the organelles that are found in eukaryotic cells. Organelles are small, membraneous bodies, each with a specific structure and function. Prokaryotes do have cytoplasm, the material contained by a plasma membrane and cell wall. The cytoplasm includes ribosomes (the site of protein synthesis) and enzymes. Prokaryotes also have a nucleoid, a region in the bacterial cell interior in which the DNA is physically organized but not enclosed by a membrane. Bacteria and archaebacteria are prokaryotic.



- **Eukaryotic cells** Plant, animal and fungal cells are **eukaryotic cells.** The nucleus in a eukaryotic cell is bound by a nuclear envelope and contains nucleoplasm. The cytoplasm found between the plasma membrane and the nucleus, consists of fluid and the organelles. Many organelles have membranes, such as the nucleolus, endoplasmic reticulum, Golgi apparatus, lysosomes, and chloroplast.

All cells have a few basic features in common:

1. **Plasma membrane**: a selective barrier which encloses a cell (*plant and bacteria cells also contain a cell wall*).
2. **Cytosol**: located inside the plasma membrane, this is a jelly-like fluid that supports organelles and other cellular components.
3. **Cytoplasm**: the cytosol and all the organelles other than the nucleus.
4. **Ribosomes**: the organelles on which protein synthesis takes place.
5. **DNA**: the genetic material which is contained in one or more chromosomes.

Despite the fact that all cells share the above characteristics, they can be remarkably different in size, shape and function.

The distinction *between* Prokaryotes *and* Eukaryotes

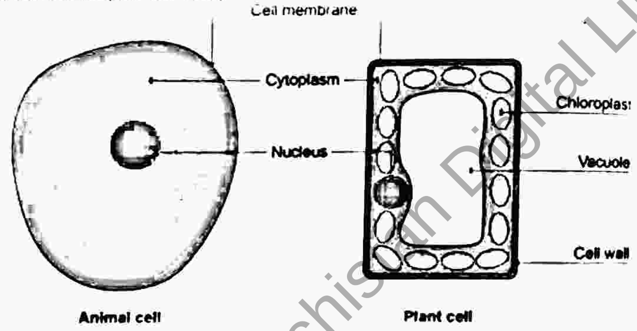
The distinction between *prokaryotes* and *eukaryotes* is considered to be the most important distinction among groups of organisms. Eukaryotic cells contain membrane-bound organelles, such as the nucleus, while prokaryotic cells do not. Differences in cellular structure of prokaryotes and eukaryotes include the presence of mitochondria and chloroplasts, the cell wall, and the structure of chromosomal DNA.

Prokaryotes were the only form of life on Earth for millions of years until more complicated eukaryotic cells came into being through the process of evolution

	Eukaryotic Cell	**Prokaryotic Cell**
Nucleus:	Present	Absent
Number of chromosomes:	More than one	One—*but not true chromosome: Plasmids*
Cell Type:	Usually multicellular	Usually unicellular (*some cyanobacteria may be multicellular*)
True Membrane bound Nucleus:	Present	Absent
Example:	Animals and Plants	Bacteria and Archaea
Genetic Recombination:	Meiosis and fusion of gametes	Partial, *undirectional transfers* DNA
Lysosomes / peroxisomes:	Present	Absent
Microtubules:	Present	Absent or rare
Endoplasmic reticulum:	Present	Absent
Mitochondria:	Present	Absent
Cytoskeleton:	Present	May be absent
DNA wrapping on proteins.	Eukaryotes wrap their DNA around proteins called histones.	Multiple proteins act together to fold and condense prokaryotic DNA. Folded DNA is then organized into a variety of conformations that are supercoiled and wound around tetramers of the HU

		protein.
Ribosomes:	larger	smaller
Vesicles:	Present	Present
Golgi apparatus:	Present	Absent
Chloroplasts:	Present (*in plants*)	Absent: chlorophyll scattered in the cytoplasm
Flagella:	Microscopic in size; membrane bound; usually arranged as nine doublets surrounding two singlets	Submicroscopic in size, composed of only one fiber
Permeability of Nuclear Membrane:	Selective	not present
Plasma membrane with steroid:	Yes	Usually no
Cell wall:	Only in plant cells and fungi (*chemically simpler*)	Usually chemically complexed
Vacuoles:	Present	Present
Cell size:	10-100um	1-10um

Cell Structure (CSS 1994/2008)



Cell or Plasma Membrane:

The cell membrane is a thin semi-permeable membrane It encloses the cytoplasm and is selectively permeable which means it is permeable to certain substances while it prevents other substances from entering the cell. It consists of three layers.

Cell wall:

Nearly all plant cells have a cell wall made of cellulose and may contain waxes and suberin. The cell wall lies outside the plasma membrane and is non living. It is tough and firm and provides support for the plant body. It is a permeable membrane. Animals have no cell wall.

Cytoplasm:

Cytoplasm is a semi fluid substance formed in a living cell. The composition includes proteins, lipids, carbohydrates water and inorganic substances. It contains all the cell organelles like mitochondria, ribosome's, nucleus, nucleolus, lysosomes, Golgi bodies, endoplasmic reticulum, plastids etc. It exhibits the important characteristics of living things like growth, nutrition, respiration, excretion, reproduction and irritability.

Cell organelles:

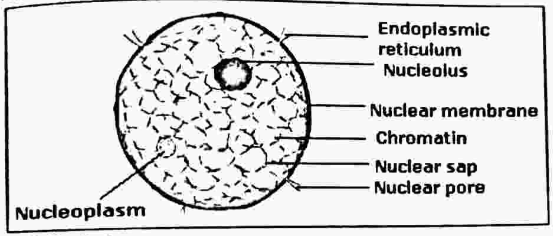
Organelles are the persistent structures that have a specialized function within the protoplasm. In most of the cases, organelles are separated from rest of the cytoplasm by a selectively permeable membrane.

Nucleus:

The nucleus is a prominent structure found in the both animal and plant cell. The Nucleus is made of two components. The nuclear membrane has pores that facilitate exchange between the cytoplasm and the nucleolus. The nucleoplasm contains a chromatin network and the nucleolus. The chromatin threads contain genes that transmit hereditary traits from one generation to another.

Nucleolus:

There is a spherical body found in the nucleoplasm called the nucleolus. It disappears when the cell is about to divide but reappears after the cell division. It appears to be active centres of protein and RNA synthesis.



Endoplasmic Reticulum:

This is a very fine structure which can be seen only through an electron microscope. The endoplasmic reticulum is a network of tube like structures distributed extensively throughout the cytoplasm. It plays an important role in the synthesis and transportation of complex biological molecules.

Ribosomes (CSS 2011)

Ribosomes are extremely minute granular or spherical structures found either in Free State in the cytoplasm or attached to the surface of endoplasmic reticulum. The main function of ribosomes is to act as a platform or work place for the synthesis of proteins.

Mitochondria: (CSS 2011)

These are small rod shaped or spherical organelles found in large numbers. Each mitochondrion is bound by two membranes; outer and inner. Their outer membrane is smooth and their inner membrane is projected with finger like structure called cristea. They have enzymes necessary for oxidation of carbohydrates and energy is released in the form Of ATP. They provide energy for the vital activities of living cells.

Golgi bodies: (CSS 2011)

This organelle is also known as golgiapparatus, discovered by Camillo Golgi in 1890, are also called as Golgi bodies. They are present in all cells except bacterial and blue-green algae cells. These structures vary in number from cell type to cell type. In secretory tissues like thyroid and liver they are present in large numbers than in other type of cells. They are abundant in secretory surfaces like stigma of the pistils.

Lysosomes (CSS 2011)

These are, small enzyme containing, single membrane-bound vesicles. Though these organelles were noticed in 1949, later it was de Duve who coined the term Lysosomes for such dense bodies. They are spherical and sac likes organelles. Many digestive enzymes are present inside them. Lysosomes are formed by Golgi complex. During starvation, lysosome acts as their own cellular organelles and digests them. This results in cell death. Thus lysosome is also referred to colloquially as 'suicidal bags'. They help in destruction of foreign bodies. Lysosomes are important cell organelles in digesting various macromolecules like carbohydrates, proteins, fats, DNA, RNA and others. The breakdown of these molecules during various stages of development and metabolism is governed by the controlled release of these enzymes

Plastids:

Plastids occur in plants cells and are absent in animal cells. Plastids have three major types.

Choloroplast:

These green plastids have owed their color to the presence of chlorophyll. These occur abundantly in green leaves, and also to some extent in the shoot of green plants. It synthesizes carbohydrates from carbon dioxide and water by the process of photosynthesis.

Amyloplast:

This plastid contains pigments other than green. These impart various color effects to flowers and fruits. These attract insects and other animals to ensure pollination and dispersal.

Leucoplasts:

They are colorless plastids occurring in seeds, meristematic cells, ground tissue of certain roots and stems. These store starch, protein, or lipids in cell.

Although there are some basic differences between a plant and an animal cell, their general structure remains the same.

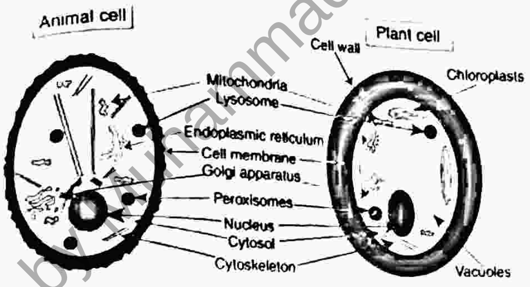
Genetic Material

Two different kinds of genetic material exist: deoxyribonucleic acid (DNA) andribonucleic acid (RNA). Most cells use DNA for their long-term information storage. The biological information contained in an organism is encoded in its DNA sequence. RNA is used for information transport (*e.g.*, mRNA) and enzymatic functions (e.g., ribosomal RNA). Transfer RNA (tRNA) molecules are used to add amino acids during protein translation.

Difference between Plant and Animal Cells

Plant and animal cells are both eukaryotic cells. However, there are distinct differences between the cells found in plants and those found in animals.

Below is a list of the major differences:



Animal Cells	Plant Cells
Does not have a cell wall, irregular in shape	Has a cell wall, regular in shape
No chloroplast present	Chloroplast present
Small temporary vacuoles or no vacuole	Large vacuoles located in the centre of cell
Starch grains not present	Starch grains present
The nucleus is usually located centrally	Due to the central location of the vacuole, the nucleus of the cell may be located at the edge of the cell
Cytokinesis takes place by constriction during cell division	Cytokinesis takes place by cell plate formation
Animal cells possess cenrosome and centrioles	Centrosome and centrioles have not been found in plant cells (*except in a few lower plants)*
Plastids are absent	Plastids (*leucoplast, chloroplast, and chromoplast*) are present in plant cells.
Cell is absent	The plasma membrane of a plant cell is surrounded by a rigid cell wall made up of cellulose
Animal cells have a single highly elaborate Golgi complex	Plant cells have many simpler units of Golgi complex, called dictyosomes.
Organelles Cell membrane Nuclear membrane One or more small vacuoles Centrioles Cytoplasm Endoplasmic Reticulum Ribosomes	**Organelles** Cell membrane Cell wall Nuclear membrane Plasmodesma Large Vacuole Plastids Chloroplast

Mitochondria	Leucoplast
Golgi Apparatus Microtubules/	Chromoplast
Microfilaments	Golgi Bodies
Flagella in some cells	Ribosome
Lysosomes	Endoplasmic reticulum
Nucleus	Mitochondria
Cilia	Lysosome
DNA	Cytoplasm
	Nucleus
	DNA
	Chromatin
	RNA
	Cytoskeleton
	Nucleolus

Cell Division

Cell division is the process by which a *parent cell* divides into two or more *daughter cells*. Cell division usually occurs as part of a larger cell cycle.

Cell division is the first stage of growth in living organisms whereby cells divide to form new cells. In *unicellular organisms* cell division is a process of asexual reproduction. It leads to an increase in the total number of individuals. On the other hand, in *multicellular organisms* the division of all cells, other than the reproductive cells, is known as *mitosis*. In mitosis is cell division an aspect of growth and is accompanied by cellular enlargement and differentiation.

Why do cells divide?

Cell divides so that organisms can grow. In order for organisms to grow, body cells either have to increase their size or divide. Most cells divide, because smaller is better when it comes to cells.

- Cell growth
- Repair & replacement of damaged cell parts
- Reproduction of the species

Why do cells need to stay small? Why don't cells just keep getting bigger instead of multiplying?

Cells are limited in size because the outside (the plasma membrane) must transport food and oxygen to the inside of the cell. This can be represented by what is known as the surface to volume ratio. As a cell gets bigger, the outside is unable to keep up with the inside, because the inside grows at a faster rate than the outside. This is a problem because cells obtain nutrients and get rid of wastes through a process called diffusion. Diffusion works faster over short distances and takes longer over long distances. So if a cell grows larger instead of dividing, diffusion will be too slow and the cell will not be able to obtain nutrients and get rid of wastes efficiently, which ultimately would kill the cell. Thus, cells divide so that an organism can get bigger, despite the fact that cell size is limited.

Cells also divide to replace damaged or dying cells.

The Cell Cycle

- **Interphase** describes the period between cell divisions. Although it may seem as though the cell is inactive during interphase, quite the opposite is true. During this phase (the longest phase of the cell cycle) the cell grows, DNA is replicated and the centrioles divide.

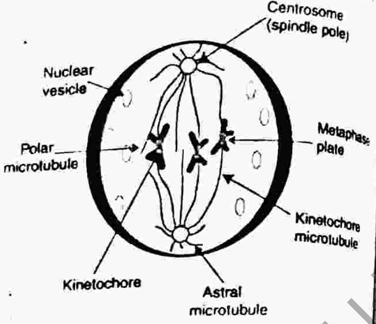
Interphase is divided into the following three sub phases:

- **G1 phase** or "first gap" is a growth phase for the cell.
- **S phase** or "synthesis" is when the cell copies its chromosomes.
- **G2 phase** or "second gap" is a second growth phase where further growth and preparations for division occur.

Mitosis (M Phase) is the process of nuclear division and is divided into the following phases:

Prophase is the first mitotic phase. During prophase the nucleoli disappear and the chromatin (DNA and associated proteins) condenses into discrete chromosomes that are observable with a light microscope. Each replicated chromosome is composed of two sister chromatids, both containing the same genetic information. The sister chromatids are joined together at their centromeres. The mitotic spindle forms from the centrioles and begins to elongate. As the centrioles reach opposite ends of the cell the spindle fibers from each of the centrioles attach to each chromosome at a specialized protein structure called the kinetochore. The kinetochore is located at the centromere of each chromosome. Other spind. fibers elongate, but instead of attaching to chromosomes, they interact with spindle from the opposite pole.

Metaphase is the longest stage of mitosis. It is during this stage that the tension applied by the mitotic spindle fibers aligns all of the chromosomes along the metaphase plate, an imaginary line the divides the cell in two. This organization is necessary to ensure that in the next phase, whe the chromosomes are separated, each new nucleus will receive one copy of each chromosome. Metaphase can occupy a large portion of the total time of mitosis because chromosome alignment at the center of the cell on the metaphase plate acts as a checkpoint for progression into the next phase, anaphase. Cells can arrest in metaphase for days until the chromosomes are properly aligned and the cell enters anaphase.



Mitosis involves a five step process, and then a final, culminating sixth step, called cytokinesis.

The five steps of mitosis, called prophase, prometaphase, metaphase, anaphase, and telophase, constitute the period in which the cell makes preparations for cell division. The five phases are differentiated by specific events of preparation for cell division. Cytokinesis refers to the actual cleavage event, splitting the cell in two.

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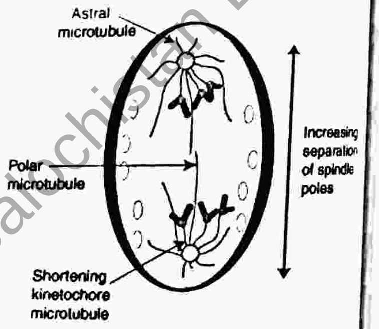
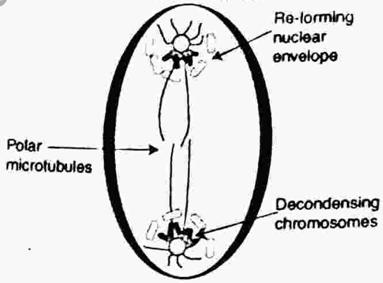
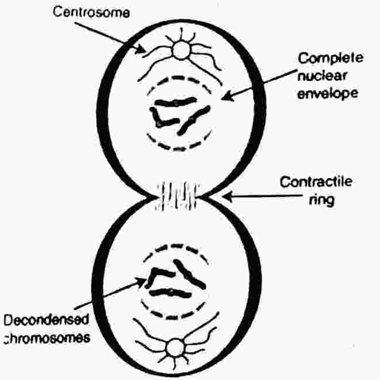


Anaphase is the shortest stage of mitosis. The spindle fibers shorten during anaphase, pulling the sister chromatids apart towards opposite ends of the cell. Entrance into anaphase is triggered by the inactivation of M phase-promoting factor that follows mitotic cyclin degradation. During anaphase, the kinetochore microtubules retract, increasing the seperation of the sister chromatids as they are moved further toward the opposite spindle poles Anaphase can be broken into two distinct phases. In the first phase, called*anaphase A*, chromosomes move poleward, away from the metaphase plate with the retraction of the microtubules. This movement occurs at approximately 2 micrometers per minute (the entire length of a cell is between 10 and 30 micrometers). In the second phase, *anaphase B*, the mitotic poles marked by the centrosomes themselves separate by the elongation of a specific type of non-kinetochore microtubule, called a polar microtubule. The extent of the separation of the poles varies from species to species. The entire duration of anaphase is relatively short, usually only lasting a few minutes

The final two events of M phase are the re-forming of the nuclear envelope around the separated sister chromatids and the cleavage of the cell. These events occur in telophase and cytokinesis, respectively.



Telophase is technically the final stage of mitosis. Its name derives from the Latin word *telos* which means end. During this phase, the sister chromatids reach opposite poles. The small nuclear vesicles in the cell begin to re-form around the group of chromosomes at each end. As the nuclear envelope re-forms by associating with the chromosomes, two nuclei are created in the one cell. Telophase is also marked by the dissolution of the kinetochore microtubules and the continued elongation of the polar microtubules. As the nuclear envelopes re-form, the chromosomes begin to decondense and become more diffuse.

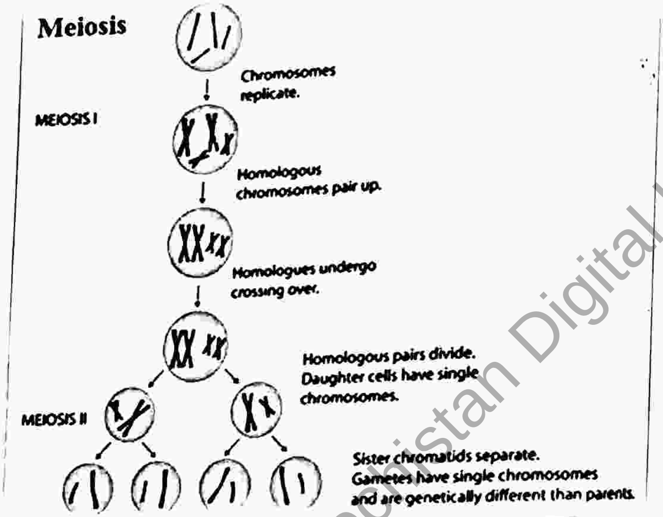


Cytokinesis describes the division of the cytoplasm and while it is not a stage of mitosis (nuclear division), but does result in the completion of cell division and the end of the cell cycle. In animal cells, cytokinesis involves the formation of a cleavage furrow, which pinches the cell into two distinct daughter cells. Cytokinesis is the process in which the cell actually divides into two. With the two nuclei already at opposite poles of the cell, the cell cytoplasm separates, and the cell pinches in the middle, ultimately leading to cleavage. In most cells, the mitotic spindle determines the site where the cell will begin to invaginate and split. The first signs of this puckering are usually visible sometime during anaphase.

The cell's cytoskeleton becomes disassembled. The disassembled cytoskeletal filaments are used in a different way during cytokinesis. Cleavage occurs by the contraction of a thin ring of actin filaments that form the contractile ring. The contractile ring defines the cleavage line for the cell. If the ring is not positioned at the center of the cell, an asymmetrical divisi takes place. The ring contracts and eventually pinches the cell until it separates into tw independent daughter cells. In higher order plants, the cytokinesis process is slightly differen because the cytoplasm splits with the formation of the cell wall.

Meiosis

Meiosis is the type of cell division used to produce **gametes** (sperm and eggs). Meios assures that genetic diversity is achieved during sexual reproduction. Meiosis consists of 2 cel divisions: Meiosis I and Meiosis II. Meiosis starts with a diploid (2n) parent cell that divides t make 4 haploid (n) cells. In sexual reproduction, haploid gametes from two different individual combine to produce a diploid zygote. The resulting offspring is genetically different from both parents.


Meiosis
Chromosomes replicate.
MEIOSIS I
Homologous chromosomes pair up.
Homologues undergo crossing over.
Homologous pairs divide. Daughter cells have single chromosomes.
MEIOSIS II
Sister chromatids separate. Gametes have single chromosomes and are genetically different than parents.

Chromosome characteristics:

Haploid (n) = one set of chromosomes
Diploid (2n) = two sets of chromosomes
Eggs and sperm (gametes) are haploid
Diploid set for humans: 2n = 46
Interphase before Meiosis: During the interphase preceding meiosis, DNA replication takes place.

Meiosis I

- **Prophase I:** Homologous chromosomes pair up and form tetrads. This pairing is known as synapsis. While paired, the homologous chromosomes exchange genetic material in a process called crossing over. Crossing over contributes to the genetic variation of sexual reproduction. While all this is occurring, the nuclear envelope and nucleoli begin to disappear. Spindle fibers attach to the chromosomes and begin moving them to the equatorial plate.
- **Metaphase I**: Homologous chromosomes, in a pair-wise fashion, have lined up on the equatorial plate. One homologue is positioned on each side of the equatorial plate. The orientation is random, which means that there is a 50-50 chance for the daughter cells to get either the maternal or paternal homologue for each chromosome. This is known as independent assortment.
- **Anaphase I**: Chromosomes from each pair move to opposite poles of the cell. Each chromosome still consists of two sister chromatids.
- **Telophase I**: Nuclear envelopes may reform, or the cell may immediately start meiosis II. DNA replication does NOT take place. There are now only a haploid number of chromosomes in each cell.

Summary of Meiosis I: *Crossing over occurs between homologous chromosomes. Homologous chromosomes separate from each other and 2 haploid cells are formed.*

Meiosis II

- **Prophase I**: Chromatin once again condenses into discrete chromosomes. The spindle apparatus forms.
- **Metaphase II**: Chromosomes are lined up along the equatorial plate, similar to metaphase in mitosis. Due to crossing over in meiosis I, the two sister chromatids of each chromosome are no longer genetically identical. Microtubules from opposite poles attach to each sister chromatid of a chromosome.
- **Anaphase II**: Sister Chromatids separate and move toward opposite poles as individual chromosomes.
- **Telophase II**: Chromosomes decondense and nuclear envelopes reform. Meiotic division has produced 4 daughter cells, each with a haploid set of chromosomes and each chromosome has only one chromatid. Each of the 4 daughter cells is genetically distinct from each other and the parent cell.

Summary of Meiosis II: *Sister chromatids separate from each other (similar to mitosis) and 4 haploid gamete cells are formed.*

Mitosis vs. Meiosis

Property	**Mitosis**	**Meiosis**
DNR Replication	Occurs during interphase before mitosis begins	Occurs during interphase before meiosis begins
Number of Divisions	One	Two
Synapsis oh homologous chromosomes	Does not occurs	Occurs alongwith crossing over between non-sister chromatids in prophase I
Number of daughter cells and genetic composition	Two diploid (2n) daughter cells that are genetically identical to the parent cell	4 haploid (n) daughter cell, each contaning half as many chromosomes as the parent

Role in the animal body	Produces cells for growth and repair	cell. Daughter cells are genetically different from the parent cells and each other. Produces gametes and assures genetic diversity in sexual reproduction.

What is Reproduction?

Reproduction is the process by which new organisms are generated. It is the mechanism of species continuation. There are two means of reproducing: asexual and sexual reproduction. When two lions mate, they produce lion cubs as offspring. Bee carrying pollen from one daisy to another fertilizes it, causing it to reproduce in the form of fertilized seeds. In these and all other examples of reproduction, new individuals are created from existing ones.

Asexual *(vegetative)* Reproduction

- A form of duplication using only mitosis.
- Example, a new plant grows out of the root or a shoot from an existing plant.
- Produces only genetically identical offspring since all divisions are by mitosis

1. Offspring called clones meaning that each is an exact copy of the original organism
2. This method of reproduction is rapid and effective allowing the spread of an organism
3. Since the offspring are identical, there is no mechanism for introducing diversity

Sexual Reproduction

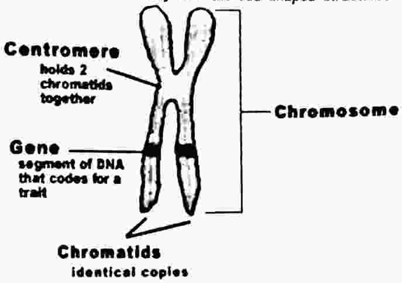
- Formation of new individual by a combination of two haploid sex cells (gametes).
- Fertilization- combination of genetic information from two separate cells that have one half the original genetic information
- Gametes for fertilization usually come from separate parents
    1. Female- produces an egg
    2. Male produces sperm
- Both gametes are haploid, with a single set of chromosomes
- The new individual is called a zygote, with two sets of chromosomes (diploid).
- Meiosis is a process to convert a diploid cell to a haploid gamete, and cause a change in the genetic information to increase diversity in the offspring

Asexual Reproduction vs Sexual Reproduction

	Asexual Reproduction	**Sexual Reproduction**
No of organisms involved:	One parent needed.	Two parents are required to mate
Cell division:	Cells divide by Fission, budding , or regeneration	Cells divide by Meiosis
Types:	Budding, vegetative reproduction, fragmentation, spore formation	Syngamy and conjugation
Advantage	Time Efficient; no need to search for mate, requires less energy	Variation, Unique., organism is more protected
Disadvantages:	No variation - if the parent has a genetic disease, offspring does too.	Requires two organisms, requires more energy
Evolution:	There is very little chance of variation with asexual reproduction. Mutations in DNA can still occur but not nearly as frequently as sexual reproduction.	Sexual reproduction leads to genetic variation in new generations of offspring. This is fundamental to evolution
Involvement of sex cells:	No formation or fusion of gametes(sex cell)	Formation or fusion of gametes(sex cell) occurs
Found in:	lower organisms	Higher invertebrates and all vertebrates
Unit of reproduction:	May be whole parent body or a bud or a fragment or a single somatic cell	gamete
Time period	Less	More
No of offsprings produced:	2 (minimum) or more than 2	1(minimum) or more than 1

Chromosomes

DNA, found in the nucleus of plant and animal cells, is organized into structures called **chromosomes**. Cell biologists in the nineteenth century saw the rod shaped structures within cell nuclei and named the structures "chromosomes" because of the way they absorb colored stain. Later it was determined that those rod shaped structures held the genetic information (DNA) that was transferred from generation to generation. This DNA provides the instruction manual for life, informing an animal or plant how to grow, develop, and function. A single, continuous strand of DNA is tightly coiled into the chromosome structure. Proteins such as histones help package the DNA and aid in its function.

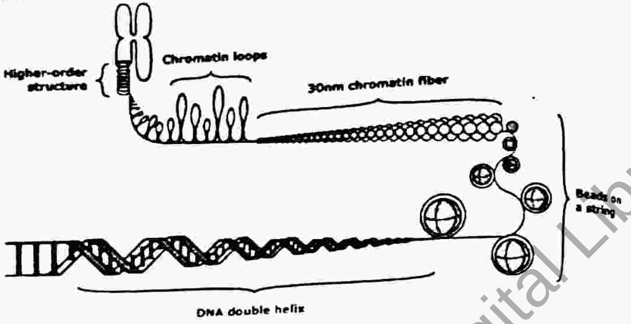

Centromere
holds 2 chromatids together
Chromosome
Gene
segment of DNA that codes for a trait
Chromatids
identical copies

A human typically has 46 chromosomes (23 pairs) in every cell of his or her body. One copy of each chromosome pair is inherited from the mother, while the other copy of each chromosome is inherited from the father. Twenty-two of the twenty-three chromosome pairs are called**autosomes** (non-sex chromosomes) which carry the same types of genetic information in both men and women. The final pair of chromosomes is called the sex chromosomes and determine gender, among other traits. A female typically has two X sex chromosomes while a male has a X and a Y. As mentioned previously, chromosomes come in matching (homologous) pairs. **Homologous** is a word that describes two chromosomes that carry the same types of information. While the sequence on the two homologous chromosomes may not be identical, the chromosomes have variations of the same genes. Variations of a specific gene are also known as alleles.

There are several important chromosome structures with which you should be familiar. A chromosome **telomere** is the region at each end of the chromosome. A chromosome **centromere** is the region of the chromosome where the chromosome attaches to its matching **homolog** during replication. This centromere can be in the middle of the chromosome or closer to an end. The centromere divides the chromosome into two segments called "arms." The shorter segmen called the "short arm" (**p** arm) while the longer segment is called the "long arm" (**q** arm).

Chromosome Structure and its characteristics

In every living cell in the human body, there are long strands of DNA that carry gen information and are called chromosomes. The structure of the chromosome is supported b histones which are in fact DNA that is coiled around proteins. Chromosomes within the nuc of the cell are not visible to the human eye. The only time it can be seen is when cell div takes place and that also only through a microscope. Therefore, whatever scientists have lea about chromosomes has been by making observations at the time of cell division.



Visible characteristics of the Chromosome

The most visibie part of the chromosome is its central construction point known as the centromere which branches into what is called two "arms". Each chromosome consists of two or four arms that extend from the centromere with the longer of the arms being known as the "q" arm and the shorter arm as "p" arm. It is the centromere that is responsible for the shape of the chromosome and also plays a major roll in cell division. It also helps to identify where a specif gene is located. A common method of identifying this is by determining the position of the centromere on the chromosome as follows:

- **Metacentric** – Centromere is positioned in the center of the chromosome with arms of equal length.
- **Submetacentric** – Centromere is closer to the center but arms are of different lengths
- **Acrocentric** – Centromere is positioned closer to one end with a big difference in arm lengths.
- **Telocentric** – Centromere is at the extreme end and has only one arm.

Chromosomes in Human Cell

Under normal circumstances, there are 23 pairs of chromosomes in a human cells making it 46 chromosomes altogether in each cell. It is when the number of cells differ from the above number that problems occur in the carrying of bodily functions, its development and other health issues. These changes usually occur during the initial stages of the development of the fetus when

the eggs and sperm come together. It can however happen even after birth and this phenomenon which can be more than 46 chromosomes or less is called aneuploidy.

Male and Female Chromosomes

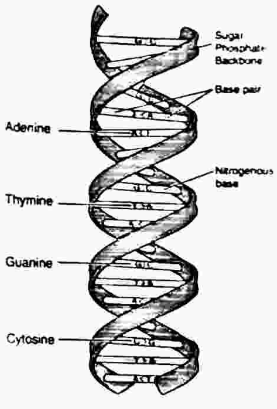
Out of the 23 pairs of chromosomes found in each cell, 22 pairs look exactly the same in males and females and is known as autosomes. These are also numbered according to their size. It's the 23rd pair that creates the difference between male and female and are generally referred to as the sex chromosomes where the male has one X and one Y chromosome while females have two of the same X chromosome.

In some rare instances, a cell can have an extra set of chromosomes which is known as triploid or even two extra sets called tetraploid. It's even rarer to come across a person who has an additional set of chromosomes for each cell in the body because it's not possible for such a person to live. The numbers of chromosomes in cancer cells also change and this is not an inherited condition but one that takes place in the cells during the formation of a cancerous tumor.

Nucleic Acids (CSS 2011)

Nucleic acids are essential large biological molecules for all forms of life. The nucleic acids include the DNA *(deoxyribonucleic acid)* and the RNA *(ribonucleic acid)*.

Nucleic acids are essential large biological molecules for all forms of life. The nucleic acids include the DNA and the RNA. They are the hereditary determinants of living organisms. They are present in most living cells either in Free State or bound to proteins as nucleoproteins. The nucleic acids are biopolymers with mononucleotides ad their repeating units. The monomers are known as nucleotides, they are made up of three units: a sugar, an amine and a phosphate group.



Deoxyribonucleic Acid

The human body produces billions of new cells every day. But before undergoing cell division, a cell must first copy the genetic information contained in the cell nucleus – its DNA

Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions for the development and function of living things.All known cellular life and some viruses contain DNA. The main role of DNA in the cell is the long-term storage of information. It is often compared to a blueprint, since it contains the instructions to construct other components of the cell, such as proteins and RNA molecules.

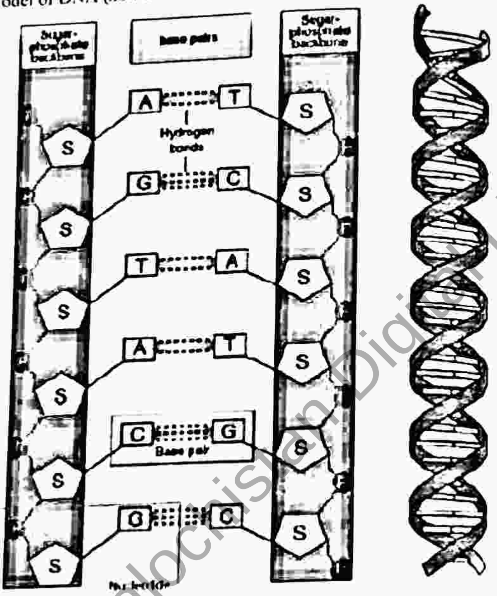
A DNA molecule consists of two strands that wrap around each other to resemble a twisted ladder. The sides are made of sugar and phosphate molecules. The "rungs" are made of nitrogen-containing chemicals called bases. Each strand is composed of one sugar molecule, one phosphate molecule, and a base. Four different bases are present in DNA - adenine (A), thymine (T), cytosine (C), and guanine (G). The particular order of the bases arranged along the sugar - phosphate backbone is called the DNA sequence; the sequence specifies the exact genetic instructions required to create a particular organism with its own unique traits.

Each strand of the DNA molecule is held together at its base by a weak bond. The four bases pair in a set manner: Adenine (A) pairs with thymine (T), while cytosine (C) pairs with guanine (G). These pairs of bases are known as Base Pairs (bp).

Molecular model of DNA structure: A molecular model for DNA structure first proposed by J.D Watson and F.H.C Crick (1953) has been universally accepted. They were awarded Nobel Prize for their discovery. The work of Crick and Watson has been supported by X-ray diffraction picture obtained by Wilkins and his associates.

The double helical structure of DNA was proposed by James Watson and Francis Crick in 1953. The structure of DNA double helix is comparable to a twisted ladder. The salient features of Watson - Crick Model of DNA (*now known as* B-DNA) are given below

Main Features of Watson/Crick Model



1. The DNA is a right handed double helix. It consists of two polydeoxyribonucleotide chains (strands) twisted around each other on a common axis.
2. The two strands are antiparallel, i.e; one strand runs in the 5' to 3' direction while the other in 3' to 5' direction.
3. The width (or diameter) of a double helix is 20A° (2nm).
4. Each turn (pitch) of the helix is 34 A° (3.4nm) with 10 pairs of nucleotides, each pair placed at distance of about 3.4 A°.
5. The two polynucleotide chains are not identical but complementary to each other due to base pairing.
6. The two strands are held together by hydrogen bonds formed by complementary base pairs. The A-T pair has 2 hydrogen bonds while G-C pair has 3 hydrogen bonds. The G≡C is stronger by about 50% than A=T.
7. The hydrogen bonds are formed between a purine and a pyrimidine only.

8. The complementary base pairing in DNA helix proves Chargaff's rule(A=T, and G=C)
9. Thymine pairs with adenine by 2 hydrogen bonds. Cytosine pairs with guanine by 3 hydrogen bonds.

Different forms of DNA double helix:

The double helical structure of DNA exists in at least 6 different forms A to E and Z. Among these B, A and Z forms are important. The B-form of DNA double helix described by Watson and Crick is the most predominant form under physiological conditions.

Each turn of the B-form has 10 base pairs spanning a distance of 3.4nm. The width of the double helix is 2nm. Helix sense is right handed in A and B form of DNA and left handed in Z form of DNA. Form A contains 11 base pairs per turn while Z contains 12 base pairs. The polynucleotide strands of Z-DNA move in a somewhat zig-zag' fashion, hence the name Z-DNA. **Size of the DNA:** DNA molecules are huge in size. On an average, a base pair of B-DNA with a thickness of 0.34nm has a molecular weight of 660.

Ribonucleic Acid (RNA)

Ribonucleic acid forms the genetic material in smaller organisms namely viruses. RNA is important in the production of proteins in living organisms. RNA can move around in the cells of living organisms and serves as a genetic messenger, passing the information stored in the cell's DNA from the nucleus to other parts of the cell for protein synthesis. The 4 bases found in RNA are adenine (A), cytosine (C), and guanine (G). RNA does not contain thymine, instead, the fourth nucleotide present in RNA is the base uracil (U).RNA is a single stranded structure.

The DNA is organized into genes, the fundamental units of genetic information. The genes control the protein synthesis through the mediation of RNA. RNA performs several functions, carried out by three different types of RNAs. There are three primary types of RNA - messenger RNA (**mRNA**), transfer RNA (**tRNA**), and ribosomal RNA (**rRNA**). RNAs are made by copying a portion of the DNA and are largely involved in making proteins, though in eukaryotes, another minor type of RNA, called small nuclear RNA (snRNA) is involved in processing of the other three types of RNA.

1. **Messenger RNA** (mRNA) specifies the sequence of amino acids in the protein synthesis (translation). This carries information from the nucleus to the ribosomes which are sites for protein synthesis. The coding sequence on the mRNA determines the amino acid sequence in the protein. The mRNA is a straight molecule extends from the 5' to 3' end. It is transcribed from a DNA template. On the mRNA nucleotides are arranged into codons consisting of 3 bases each. Each such codon specifies an amino acid.
2. **Ribosomal RNA** (rRNA) is found in combination with proteins and is associated with the structure and function of ribosomes, the factories of protein synthesis. This is the Ribosomal RNA. The rRNA is synthesized in the nucleolus. In the cytoplasm, ribosomal RNA and protein combine together to form a nucleoprotein called a ribosomes. The ribosomes and mRNA bind to carry out protein synthesis. rRNA is very abundant in the cell and forms about 80% of the total RNA. The ribosomal RNAs form two subunits namely; the large subunit and small subunit. The Eukaryotic cells have 4 different types of rRNA namely; 28S rRNA, 18S rRNA, 5.8S rRNA and 5S rRNA. These different rRNA occur in the different ribosomal subunits depending on whether Eukaryotic or Prokaryotic.
3. **Transfer RNA** (tRNA) delivers the amino acids to ribosomes for protein synthesis. This RNA type is a small chain of about 80 nucleotides. As the name suggests, tRNA transfers

specific amino acid molecules to a growing polypeptide chain. The tRNA has a clov leaf model with 5 arms each with a specific function. The tRNA also has an anticod region that can base pair with the codon region on the mRNA.

Difference *between* DNA *and* RNA (CSS 2012)

	DNA	RNA
Stands for:	Deoxyribonucleic Acid	Ribonucleic Acid
Definition:	A nucleic acid that contains the genetic instructions used in the development and functioning of all modern living organisms (scientists believe that RNA may have been the main genetic material in primitive life forms).	A single-stranded chain of alternating phosphate and ribose units with the bases Adenine, Guanine, Cytosine, and Uracil bonded to the ribose. RNA molecules are involved in protein synthesis and sometimes in the transmission of genetic information.
Job/Role	Medium of long-term storage and transmission of genetic information	Transfer the genetic code needed for the creation of proteins from the nucleus to the ribosome
Unique Features:	The helix geometry of DNA is of B-Form. DNA is completely protected by the body, i.e.. the body destroys enzymes that cleave DNA. DNA can be damaged by exposure to Ultra-violet rays	The helix geometry of RNA is of A-Form. RNA strands are continually made, broken down and reused. RNA is more resistant to damage by Ultra-violet rays.
Predominant Structure:	Double- stranded molecule with a long chain of nucleotides	A single-stranded molecule in most of its biological roles and has a shorter chain of nucleotides
Bases & Sugars:	Deoxyribose sugar; phosphate backbone; Four bases: adenine, guanine, cytosine and thymine	Ribose sugar; phosphate backbone. Four bases: adenine, guanine, cytosine, and uracil
Pairing of Bases:	A-T(Adenine-Thymine), G-C(Guanine-Cytosine)	A-U(Adenine-Uracil), G-C(Guanine-Cytosine)
Stability:	Deoxyribose sugar in DNA is less reactive because of C-H bonds. Stable in alkaline conditions. DNA has smaller grooves, which makes it harder for enzymes to "attack" DNA	Ribose sugar is more reactive because of C-OH (hydroxyl) bonds. Not stable in alkaline conditions. RNA has larger grooves, which makes it easier to be attacked by enzymes.
Propagation:	DNA is self-replicating.	RNA is synthesized from DNA when needed

Heredity & Genetics

Heredity

Heredity is the transmission of characteristics, physical or mental from parents to offspring. this is from one generation to the successive generation.

Meaning of Heredity

Heredity may be defined as the transmission of characteristics through generations. The characteristics include all physical, physiological and psychological characteristics in organisms. All these characteristics are called the traits.

Mendel's Work

Gregor Mendel was the first to carry out scientific studies on transmission of characteristics from the parent to the offspring. He selected garden peas as they showed many contrasting traits that were easy to track through the generations.

Genetics

Genetic Terms

- **Gene** - a unit of inheritance that usually is directly responsible for one trait or character.
- **Allele** - an alternate form of a gene. Usually there are two alleles for every gene, sometimes as many a three or four.
- **Homozygous** - when the two alleles are the same.
- **Heterozygous** - when the two alleles are different, in such cases the dominant allele is expressed.
- **Dominant** - a term applied to the trait (allele) that is expressed irregardless of the second allele.
- **Recessive** - a term applied to a trait that is only expressed when the second allele is the same (e.g. short plants are homozygous for the recessive allele).
- **Phenotype** - the physical expression of the allelic composition for the trait under study.
- **Genotype** - the allelic composition of an organism.
- **Punnett squares** - probability diagram illustrating the possible offspring of a mating.

Genetics

Genetics is the study of how genes bring about characteristics, or traits, in living things and how those characteristics are inherited. Genes are portions of DNA molecules that determine characteristics of living things. Through the processes of meiosis and reproduction, genes are transmitted from one generation to the next.

The Augustinian monk Gregor Mendel developed the science of genetics. Mendel performed his experiments in the 1860s and 1870s, but the scientific community did not accept his work until early in the twentieth century. Because the principles established by Mendel form the basis for genetics, the science is often referred to as *Mendelian genetics*. It is also called *classical genetics* to distinguish it from another branch of biology known as molecular genetics.

Mendel believed that factors pass from parents to their offspring, but he did not know of the existence of DNA. Modern scientists accept that **genes** are composed of segments of DNA molecules that control discrete hereditary characteristics.

Most complex organisms have cells that are diploid. **Diploid** cells have a double set of chromosomes, one from each parent. For example, human cells have a double set of chromosomes consisting of 23 pairs, or a total of 46 chromosomes. In a diploid cell, there are two genes for each characteristic. In preparation for sexual reproduction, the diploid number of chromosomes is reduced to a haploid number. That is, diploid cells are reduced to cells that have a single set of chromosomes. These haploid cells are **gametes**, or sex cells, and they are formed through meiosis. When gametes come together in sexual reproduction, the diploid condition is reestablished.

The offspring of sexual reproduction obtain one gene of each type from each parent. The different forms of a gene are called **alleles**. In humans, for instance, there are two alleles for earlobe construction. One allele is for earlobes that are attached, while the other allele is for earlobes that hang free. The type of earlobe a person has is determined by the alleles inherited from the parents.

The set of all genes that specify an organism's traits is known as the organism's **genome**. The genome for a human cell consists of about 100,000 genes. The gene composition of a living organism is its **genotype**. For a person's earlobe shape, the genotype may consist of two genes for attached earlobes, or two genes for free earlobes, or one gene for attached and one gene for free earlobes.

The expression of the genes is referred to as the **phenotype** of a living thing. If a person has attached earlobes, the phenotype is "attached earlobes." If the person has free earlobes, the phenotype is "free earlobes." Even though three genotypes for earlobe shape are possible, only two phenotypes (attached earlobes and free earlobes) are possible.

The two paired alleles in an organism's genotype may be identical, or they may be different. An organism's condition is said to be **homozygous** when two identical alleles are present for a particular characteristic. In contrast, the condition is said to be **heterozygous** when two different alleles are present for a particular characteristic. In a homozygous individual, the alleles express themselves. In a heterozygous individual, the alleles may interact with one another, and in many cases, only one allele is expressed.

When one allele expresses itself and the other does not, the one expressing itself is the **dominant** allele. The overshadowed allele is the **recessive** allele. In humans, the allele for free earlobes is the dominant allele. If this allele is present with the allele for attached earlobes, the allele for free earlobes expresses itself, and the phenotype of the individual is "free earlobes." Dominant alleles always express themselves, while recessive alleles express themselves only when two recessive alleles exist together in an individual. Thus, a person having free earlobes can have one dominant allele or two dominant alleles, while a person having attached earlobes must have two recessive alleles.

Mutation

A gene mutation is a permanent change in the DNA sequence that makes up a gene. Mutations range in size from a single DNA building block (DNA base) to a large segment of a chromosome.

Gene mutations occur in two ways: they can be inherited from a parent or acquired during a person's lifetime. Mutations that are passed from parent to child are called hereditary mutations or germline mutations (because they are present in the egg and sperm cells, which are also called germ cells). This type of mutation is present throughout a person's life in virtually every cell in the body.

Mutations that occur only in an egg or sperm cell, or those that occur just after fertilization, are called new (de novo) mutations. De novo mutations may explain genetic disorders in which an affected child has a mutation in every cell, but has no family history of the disorder.

Acquired (or somatic) mutations occur in the DNA of individual cells at some time during a person's life. These changes can be caused by environmental factors such as ultraviolet radiation from the sun, or can occur if a mistake is made as DNA copies itself during cell division. Acquired mutations in somatic cells (cells other than sperm and egg cells) cannot be passed on to the next generation.

Mutations may also occur in a single cell within an early embryo. As all the cells divide during growth and development, the individual will have some cells with the mutation and some cells without the genetic change. This situation is called mosaicism.

Some genetic changes are very rare; others are common in the population. Genetic changes that occur in more than 1 percent of the population are called polymorphisms. They are common enough to be considered a normal variation in the DNA. Polymorphisms are responsible for many of the normal differences between people such as eye color, hair color, and blood type. Although many polymorphisms have no negative effects on a person's health, some of these variations may influence the risk of developing certain disorders.

Genetic Disorder

A genetic disorder is a disease that is caused by an abnormality in an individual's DNA. Abnormalities can range from a small mutation in a single gene to the addition or subtraction of an entire chromosome or set of chromosomes

Types of Genetic Disorders

There are four (4) different kinds of genetic disorders – Single Gene (Mendelian or Monogenic), Multi-factorial (complex or polygenic), Chromosomal, and Mitochondrial.

Single gene inheritance

Single gene inheritance, also called Mendelian or monogenetic inheritance. This type of inheritance is caused by changes or mutations that occur in the DNA sequence of a single gene. There are more than 6,000 known single-gene disorders, which occur in about 1 out of every 200 births. These disorders are known as monogenetic disorders (disorders of a single age).

Multifactorial inheritance

Multifactorial inheritance, also called complex or polygenic inheritance. Multifactorial inheritance disorders are caused by a combination of environmental factors and mutations in multiple genes. For example, different genes that influence breast cancer susceptibility have been found on chromosomes 6, 11, 13, 14, 15, 17, and 22. Some common chronic diseases are multifactorial disorders.

Examples of multifactorial inheritance include: heart disease, high blood pressure, Alzheimer's disease, arthritis, diabetes, cancer, and obesity.

Multifactorial inheritance also is associated with heritable traits such as fingerprint patterns, height, eye color, and skin color.

Chromosome abnormalities

Chromosomes, distinct structures made up of DNA and protein, are located in the nucleus of each cell. Because chromosomes are the carriers of the genetic material, abnormalities in chromosome number or structure can result in disease. Abnormalities in chromosomes typically occur due to a problem with cell division. For example, Down syndrome or trisomy 21 is a common disorder that occurs when a person has

Mitochondrial inheritance (CSS 2011)

This type of genetic disorder is caused by mutations in the no chromosomal DNA of mitochondria. Mitochondria are small round or rod-like organelles that are involved in cellular respiration and found in the cytoplasm of plant and animal cells. Each mitochondrion may contain 5 to 10 circular pieces of DNA. Since egg cells, but not sperm cells keep their mitochondria during fertilization, mitochondrial DNA is always inherited from the female parent.

Sex-Linked Genetic Disorder

In every cell in the human body there is a nucleus, where genetic material is stored in genes. Genes carry the codes responsible for all of our inherited traits and are grouped along rod-like structures called chromosomes. Typically, the nucleus of each cell contains 23 pairs of chromosomes, half of which are inherited from each parent. Down syndrome occurs when an individual has a full or partial extra copy of chromosome 21.

This additional genetic material alters the course of development and causes the characteristics associated with Down syndrome. A few of the common physical traits of Down syndrome are low muscle tone, small stature, an upward slant to the eyes, and a single deep crease across the center of the palm - although each person with Down syndrome is a unique individual and may possess these characteristics to different degrees, or not at all.

Sex Chromosome Abnormalities

Female Genotype	Syndrome	Male Genotype	Syndrome
XX	Normal	XY	Normal
XO	Turner	XXY	Klinefelter
XXX	Triple-X	XYY	XYY

Sex Linked Genetic Disorders

Sex-linked genetic disorders are any diseases or abnormal conditions that are caused by a defective gene on the X chromosome, one of the sex chromosomes. These disorders may also involve a deviation in the number of X or Y chromosomes. Turner Syndrome, a disorder in which all or part of one of the female's X chromosomes is missing, is an example of this.

Sex-linked genetic diseases caused by a single-gene defect are recessive and affect males almost exclusively. Why? Females possess two X chromosomes; males possess an X and a Y. For a sex-linked disorder to manifest itself in a female, both of her X chromosomes would have to carry the defective gene, meaning the girl's father would have been affected by the disorder. Because most sex-linked diseases are debilitating or fatal, this is unlikely.

Examples of sex-linked disorders caused by a single gene defect on the X chromosome include:

- Duchenne muscular dystrophy, a progressive degeneration of muscle tissue
- Hemophilia, which is a deficiency in one of several blood-clotting factors and causes uncontrollable bleeding
- Fragile-X syndrome, a problem witih the FMR1 gene on the X chromosome, which can cause mental retardation

Sex-linked diseases are passed down through families through one of the X or Y chromosomes. X and Y are sex chromosomes.

The term "sex-linked recessive" usually refers to X-linked recessive.

Typical Scenarios

For a given birth, if the mother is a carrier (only one abnormal X chromosome) and the father is a normal carrier:

- 25% chance of a healthy boy
- 25% chance of a boy with disease
- 25% chance of a healthy girl
- 25% chance of a carrier girl without disease

If the father has the disease and the mother is a normal carrier:

- 100% chance of a healthy boy

- 100% chance of a carrier girl without disease

For a given birth, if the mother is a carrier and the father has the disease:

- 25% chance of a healthy boy
- 25% chance of a boy with the disease
- 25% chance of a carrier girl
- 25% chance of a girl with the disease

If the mother has the disease and the father has the disease:

- 100% chance of the child having the disease, whether boy or girl.

Female carriers can have a normal X chromosome that is abnormally inactivated. This is called "skewed X-inactivation." These females may have symptoms similar to those of males.

Evolution

In the biological sciences, evolution is a scientific theory that explains the emergence of new varieties of living things in the past and in the present; it is not a "theory of origins" about how life began. Evolution accounts for the striking patterns of similarities and differences among living things over time and across habitats through the action of biological processes such as natural selection, mutation, symbiosis, gene transfer, and genetic drift. Evolution has been subjected to scientific testing for over a century and has been (and continues to be) consistently confirmed by evidence from a wide range of fields.

Lamarckism: Theory of Inheritance of acquired characteristics

Between 1794 and 1796 Erasmus Darwin, grandfather of Charles Darwin, wrote *Zoönomia* suggesting "that all warm-blooded animals have arisen from one living filament," and "with the power of acquiring new parts" in response to stimuli, with each round of "improvements" being inherited by successive generations.

Subsequently Lamarck proposed in his *Philosophie Zoologique* of 1809 the theory that characteristics that were "needed" were acquired (or diminished) during the lifetime of an organism were then passed on to the offspring. He saw this resulting in the development of species in a progressive chain of development towards higher forms.

Lamarck based his theory on two observations, in his day considered to be generally true:

1. Individuals lose characteristics they do not require (or use) and develop characteristics that are useful.
2. Individuals inherit the traits of their ancestors.

With this in mind, Lamarck developed two laws:

- **Law of use and disuse.** "In every animal which has not passed the limit of its development, a more frequent and continuous use of any organ gradually strengthens, develops and enlarges that organ, and gives it a power proportional to the length of time it has been so used; while the permanent disuse of any organ imperceptibly weakens and deteriorates it, and progressively diminishes its functional capacity, until it finally disappears."
- **Inheritance of acquired traits.** "All the acquisitions or losses wrought by nature on individuals, through the influence of the environment in which their race has long been placed, and hence through the influence of the predominant use or permanent disuse of any organ; all these are preserved by reproduction to the new individuals which arise, provided that the acquired modifications are common to both sexes, or at least to the individuals which produce the young."

Examples of Lamarckism would include:

- Giraffes stretching their necks to reach leaves high in trees strengthen and gradually lengthen their necks. These giraffes have offspring with slightly longer necks (also known as "soft inheritance").
- A blacksmith, through his work, strengthens the muscles in his arms. His sons will have similar muscular development when they mature

Theory of Continuity of Germplasm

This was proposed by Weismann who did not agree with Lamarck's theory of inheritance of acquired characters. To prove his point, he cut off the tails of many successive generations of mice. This resulted in forced disuse of the tail. According to the theory of use and disuse, the tails should have become progressively shorter. However, this did not happen. According to Weismann, the changes affected only the somatic (vegetative) cells and did not affect the germ cells or the gametes. Only the changes that affect the germ cells and the Germplasm (the collection of genes) will be inherited by successive generations.

Darwinism

Charles Darwin and Alfred Russell Wallace proposed that nature has its own ways of selecting the best from the available species for continuation of life. Darwin became famous for his Theory of evolution by natural selection, the mechanism of which works as follows:

- Individuals of a species produce more offspring than necessary to replace themselves.
- This result in competition and struggle for existence among the individuals. Within the species, there is variation that results in minor differences between the individuals.
- Thus in the struggle for existence only the ones with the variations best adapted to their environment survive.

In this manner nature ensures the 'survival of the fittest'.

Neo-Darwinism

The theory put forth by Darwin and Wallace gained wide acceptance. However, in the light of modern evidences, it was slightly modified and called Neo-Darwinism. In Neo-Darwinism, organic evolution is by natural selection of inherited characters. It utilizes evidences from various fields such as genetics, paleontology, molecular biology, ecology and ethology (study of behavior).

Classification of Living Organisms

More than a million species of living organisms have been discovered and described so far and a large number of them are yet to be discovered. Scientists involved in this task, called taxonomists, estimate that there may be around 30 million species of living organisms of which the known number of species forms a very small percentage.

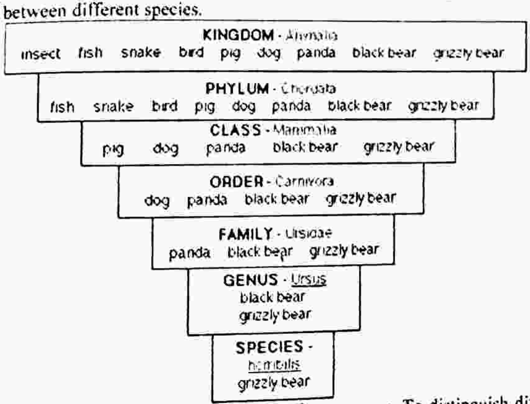
Need for Classification

More than a million species of living organisms have been discovered and described so far and a large number of them are yet to be discovered. Scientists involved in this task, called **taxonomists,** estimate that there may be around 30 million species of living organisms of which the known number of species forms a very small percentage.

Any systematic study on a given plant or animal can be made easier only when the organism is identified as one belonging to a particular group that has some specific characters. The vast number of plant and animal species that have been identified and described, exhibit a great deal of variation in their form, structure, mode of life and various other aspects. Unless the plants and animals are divided into discrete groups based on the differences and similarities between them, it becomes practically impossible to study them.

The scientific practice of identifying, naming and grouping of living organisms is called **classification.** The branches of biology that deal with classification are called**taxonomy** and **systematics**. Taxonomy, as the name indicates, deals with describing and naming organisms while systematics deals with grouping and arranging the described taxa into a hierarchical classification.

The modern taxonomic system was developed by the Swedish botanist Carolus (Carl) Linneaeus (1707-1788). He used simple physical characteristics of organisms to identify and differentiate between different species.


KINGDOM - Animalia
insect fish snake bird pig dog panda black bear grizzly bear
PHYLUM - Chordata
fish snake bird pig dog panda black bear grizzly bear
CLASS - Mammalia
pig dog panda black bear grizzly bear
ORDER - Carnivora
dog panda black bear grizzly bear
FAMILY - Ursidae
panda black bear grizzly bear
GENUS - Ursus
black bear
grizzly bear
SPECIES -
horribilis
grizzly bear

Linnaeus developed a hierarchy of groups for taxonomy. To distinguish different levels of similarity, each classifying group, called **taxon** (pl. taxa) is subdivided into other groups. To remember the order, it is helpful to use a mnemonic device. The taxa in hierarchical order:

There are **billions of different kinds** of living things (or **organisms**) on earth. To help study them, biologists have devised ways of naming and classifying them according to their similarities and differences.

The system most scientists use puts each living thing into **seven groups** (or **taxons**), organized from most general to most specific. Therefore, each species belongs to a genus, each genus belongs to a family, each family belongs to an order, etc.

From largest to smallest, these groups are:

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

Kingdom

All living organisms are first placed into different kingdoms. There are five different kingdoms to classify life on Earth, which are Animals, Plants, Fungi, Bacteria, and Protists (single-celled organisms).

Phylum

The animal kingdom is divided into 40 smaller groups, known as phylum. Here, animals are grouped by their main features. Animals usually fall into one of five different phylum which are Cnidaria (invertebrates), Chordata (vertebrates), Arthropods, Molluscs and Echinoderms.

Class

The phylum group is then divided into even smaller groups, known as classes. The Chordata (vertebrates) phylum splits up into Mammalia (Mammals), Actinopterygii (Bony Fish), Chondrichthyes (Cartilaginous Fish), Aves (Birds), Amphibia (Amphibians) and Reptilia (Reptiles).

Order

Each class is divided into small groups again, known as orders. The class Mammalia (Mammals), splits into different groups including Carnivora, Primate, Artiodactyla and Rodentia.

Family

In every order, there are different families of animals which all have very similar features. The Carnivora order breaks into families that include Felidae (Cats), Canidae (Dogs), Ursidae (Bears), and Mustelidae (Weasels).

Genus

Every animal family is then divided into small groups known as genus. Each genus contains animals that have very similar features and are closely related. For example, the Felidae (Cat) family contains genus including Felis (small Cats and domestic Cats), Panthera (Tigers, Leopards, Jaguars and Lions) and Puma (Panthers and Cougars).

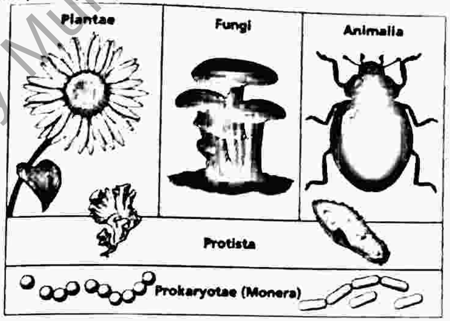
Species

Each individual species within the genus is named after its individual features and characteristics. The names of animals are in Latin so that they can be understood worldwide, and consist of two words. The first word in the name of an animal will be the genus, and the second name indicates the specific species.

The Five Kingdom System

All living things were lumped together into two kingdoms, namely plants and animals. Animals included every living thing that moved, ate, and grew to a certain size and stopped growing. Plants included every living thing that did not move or eat and that continued to grow throughout life. It became very difficult to group some living things into one or the other, so early in the past century the two kingdoms were expanded into five kingdoms:

1. Protista (*the single-celled eukaryotes*)
2. Fungi (*fungus and related organisms*)
3. Plantae (*the plants*)
4. Animalia (*the animals*)
5. Monera (*the prokaryotes*)



Many biologists now recognize six distinct kingdoms, dividing Monera into the Eubacteria & Archeobacteria.

The Three Domain System

The Three Domain System, developed by Carl Woese, is a system for classifying biological organisms.

Over the years, scientists have developed several systems for the classification of organisms. From the late 1960's, organisms had been classified according to a Five Kingdom system.

This classification system model was based on principles developed by Swedish scientist Carolus Linnaeus, whose hierarchical system groups organisms based on common physical characteristics.

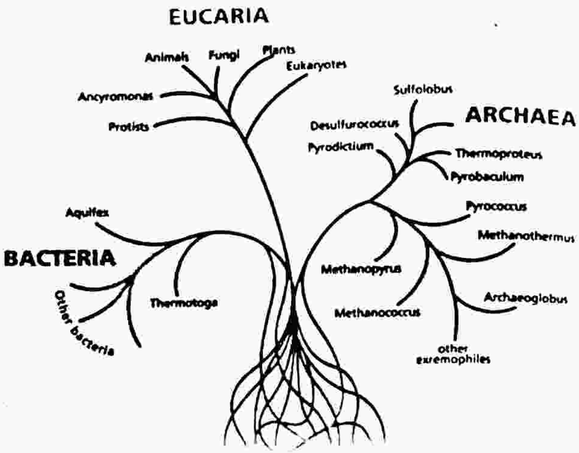
The current system, the Three Domain System, groups organisms primarily based on differences in ribosomal RNA structure. Ribosomal RNA is a molecular building block for ribosomes.

Under this system, organisms are classified into three domains and six kingdoms. The domains are Archaea, Bacteria, and Eukarya. The kingdoms are Archaebacteria (*ancient bacteria*), Eubacteria (*true bacteria*), Protista, Fungi, Plantae, and Animalia

The Archaea and Bacteria domains contain prokaryotic organisms. These are organisms that do not have a membrane bound nucleus.

Eubacteria are classified under the Bacteria domain and archaebacteria are classified as Archaeans.

The Eukarya domain includes eukaryotes, or organisms that have a membrane bound nucleus. This domain is further subdivided into the kingdoms Protista, Fungi, Plantae, and Animalia.



Six Kingdoms

All of the organisms in the world are assembled into three domains and six kingdoms

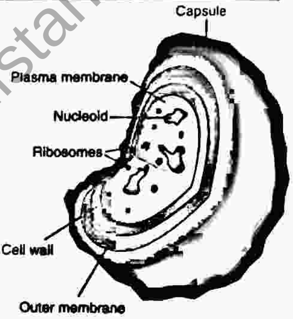
Domain: Bacteria	Kingdom Bacteria
Domain: Archaea	Kingdom Archaea
Domain: Eukarya	*Kingdom Protista*
	Kingdom Fungi
	Kingdom Plantae
	Kingdom Animalia

Members of the Bacteria and Archaea are all *prokaryotes* (before a nucleus)

Kingdom Eubacteria

Eubacteria, known as "true bacteria". The Eubacteria are one of the three main domains of life, along with the Archaea and the Eukarya Eubacteria is the only domain of the bacteria kingdom. All eubacteria are prokaryotic, meaning that their cells have no nucleus. Bacteria is also unicellular.

Eubacteria can be found almost everywhere and kill thousands upon thousands of people each year, but also serve as antibiotics producers and food digesters in our stomachs. We use Eubacteria to produce drugs, wine, and cheese.



-In our body there is more eubacteria than there are people in the world

-Most eubacteria are HELPFUL, the minority of them causes sickness and disease

Eubacteria. have a bad reputation. They are seen as disease causing agents. Every day new products come out adverstising their ability to destroy these microscopic but dangerous creatures. In reality, only a small percentage of these unicellular organisms cause disease. The rest fullfill many important roles in the natural world. Eubacteria can be photoautotrophs, saprophytes, or symbionts.

Characteristics of Eubacteria

- Eubacteria can survive in a wide range of environments.
- Some are aerobic, meaning they need oxygen to survive; while others are anaerobic, meaning they will die if oxygen is present.
- Some make their own food, autotrophic, and some obtain their food from other organisms, heterotrophic.
- There are more eubacteria than any other organism.
- Their cell walls are made of peptidoglycan. This makes their cell walls porous but strong.
- Some bacteria move and some do not. If a bacteria does move, it does so by either a flagella or cilia.
- Bacteria usually reproduce asexually (*by themself*) through the process of binary fission
- Bacteria in general are not harmful. Actually, the majority of the time bacteria helps. It helps us digest our food, create yogurt and cheese, and make antibiotics.
- Many bacteria are decomposers; they help keep dead organisms from covering the world while giving plants the nutrients that are essential to their growth.
- Because of all their helpful uses, human could not function without bacteria, we depend on them.
- Nitrogen fixing eubacteria helps in the process of nitrogen fixation which helps in maintaining the appropriate nitrogen level in the atmosphere.
- Some eubacteria are harmful and can cause meningitis, cholera, typhus, lyme's, salmonellosis, tetanus, tuberculosis, etc.
- Some of the eubacteria examples are Bacillus anthracis, Escherichia coli, Clostridium perfringens, Clostridium tetani, etc.

Kingdom Protista

Domain Eukarya

The Protista Kingdom consists of unicellular lifeforms (lifeforms with only one cell) who have a nucleus. The primary difference between protists and monera is that protists are more complex, having a nucleus. Many protists appear to be both plant and animal. Like plants, they are green, and can create their own food. However, like animals, they have moving body parts and are able to move around their environments Biologists believe that ancient protists were the ancestors of plants and animals

The protistans are conventionally divided into three categories: **protozoans** (*animal-like*), **algae** (*plant-like*), and **slime molds** (*fungus-like*). However, these categories are not evolutionarily related. We will now examine a few protozoan phyla, and one phylum of algal protistans. Currently recognized protozoan phyla are: **Rhizopoda** (amoebas), **Actinopoda** (*radiolarians and heliozoans*), **Foraminifera** (*foraminiferans*), **Apicomplexa** (*former sporozoans*), **Zoomastigophora** (flagellates), and **Ciliophora** (*ciliates*).

Characteristics of Kingdom Protista

- They are simple eukaryotic organisms.
- Most of the organisms are unicellular, some are colonial and some are multicellular like

algae.

- Most of the protists live in water, some in moist soil or even the body of human and plants.
- These organisms are eukaryotic, since they have a membrane bound nucleus and endomembrane systems.
- They have mitochondria for cellular respiration and some have chloroplasts for photosynthesis.
- Nuclei of protists contain multiple DNA strands, the number of nucleotides are significantly less than complex eukaryotes.
- Movement is often by flagella or cilia.
- Protists are multicellular organisms, they are not a plant, animal or fungus.
- Respiration - cellular respiration is primarily aerobic process, but some living in mud below ponds or in digestive tracts of animals ares strict facultative anaerobes.
- Nutrition - they can be both hetreotrophic or autotrophic.
- Flagellates are filter feeding, some protists feed by the process of endocytosis (formation of food vacuole by engulfing a bacteria and extending their cell membrane).
- Reproduction - some species have complex life cycle involving multiple organisms. Example: Plasmodium. Some reproduce sexually and others asexually.
- They can reproduce by mitosis and some are capable of meiosis for sexual reproduction.
- They form cysts in adverse conditions.
- Some protists are pathogens of both animals and plants. Example: Plasmodium falciparum causes malaria in humans.
- Protists are major component of plankton.

Kingdom Fungi

The organisms in kingdom fungi include mushrooms, yeasts, molds, rusts, smuts, puffballs, truffles, morels, and molds. More than 70,000 species of fungi have been identified. The fungi constitute and independent group to that of plants and animals. They live everywhere in air, in water, on land, in soil, and on or in plants and animals. Some fungi are microscopic and other extends for more than a thousand acres. Mycology is a discipline of biology which deals with the study of fungi. Fungi appear like plants but are closely related to animals. Fungi are not capable of producing their own food, so they get their nourishment from other sources. Fungi are in a wide variety of sizes and forms and have great economic importance.

Some of the examples of kingdom fungi are as follows:

Sac-Fungi: *Agaricus* (mushroom), *Ustilago* (smut), and *Puccinia* (rust fungus).
Zygote-Forming fungi: *Mucor, Rhizopus* (the bread mould) and *Albugo.*
Club Fungi: *Agaricus* (mushroom), *Ustilago* (smut), and *Puccinia* (rust fungus).
Imperfect Fungi: *Alternaria, Colletotrichum and Trichoderm*

Kingdom plantae

The Kingdom plantae is also called as kingdom Metaphyta. The Kingdom plantae includes all types of eukaryotic, multicellular, photosynthetic plants found in this biosphere. Most of the organism in this kingdom is autotrophs, which synthesis their own food with the help of solar energy. There are very few species, which are both autotrophs and heterotrophs. The history of life on earth and the success of many organisms literally depend on the success of plants.

This kingdom includes all types plants like herbs, shrubs, trees, creepers, climbers, aquatic plants, desert plants, mountain plants, flowering and non flowering plants, *etc.*

Animals are multicellular organisms composed of eukaryotic cells. The cells are organized into tissues and lack cell walls. They do not carry out photosynthesis and obtain nutrients primarily by ingestion. Examples include sponges, worms, insects, and vertebrates

Six Kingdoms Characteristics Chart

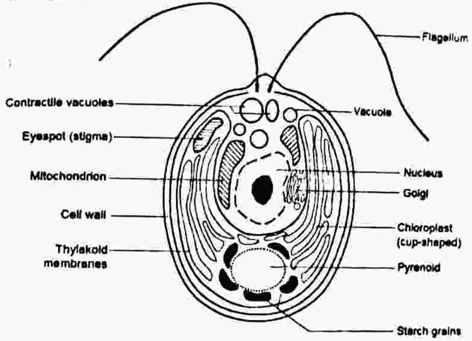
Kingdom	Cell Type	No of Cells	Cell Wall	Reprodustion	Mode of Nutrition
Eubacteria	Prokaryotic	Unicellular	Pseudomurein	Asexual	Auto/Heterotroph
Archaebacteria	Prokaryotic	Unicellular	Peptidoglycan	Asexual	Auto/Heterotroph
Protista	Eukaryotic	Most Unicellular	Various	Sexual/Asexual	Auto/Heterotroph
Fungui	Eukaryotic	Most Unicellular	Chitin	Sexual/Asexual	Heterotrophic (Decomposers)
Plantae	Eukaryotic	Unicellular	Cellulose	Sexual	Autotrophic
Animal	Eukaryotic	Unicellular	None	Sexual/Asexual	Heterotroph

Algae

Algae are in the plant kingdom, but technically they are not plants. A diverse group of organisms, algae survive in even the harshest habitats. From the dry desert, to the Arctic Circle, to boiling springs, these organisms have found a way to extract enough from their environment to live. Algae range in size from microscopic to meters long and from single-celled to complex organisms that rival large plants. These organisms may look like true plants, but unlike plants, algae do not have roots or true stems and leaves

By the modern definition, all algae are eukaryotes, which means that the DNA in their cells is contained within a nucleus enclosed by a membrane. Organisms whose cells do not have a nucleus are prokaryotes. The eukaryotes also include plants, fungi and animals. Prokaryotes include bacteria and archaea. The algae can be divided into a number of sub-groups, based largely on the types of pigments they use for photosynthesis.

Chlamydomonas



Size and Shape of Algae

Algae vary greatly in size and grow in many diverse habitats. Microscopic algae, called phytoplankton, float or swim in lakes and oceans. Phytoplankton are so small that 1000 individuals could fit on the head of a pin The largest forms of algae are seaweeds that stretch 100 m (300 ft) from the ocean bottom to the water's surface.

Habitat

Although most algae grow in fresh water or seawater, they also grow on soil, trees, a animals, and even under or inside porous rocks, such as sandstone and limestone. Algae tolera wide range of temperatures and can be found growing in hot springs, on snow banks, or dee within polar ice.

Types

The most common classification system distributes algae in more than one kingd Most algae are classified in the Kingdom Protista, along with other eukaryotic organisms th lack true specialized tissues. The cyanobacteria, however, are classified with the bacteria in th Kingdom Prokaryotae, which consists of prokaryotic organisms.

Examples:

- **Green algae** form the phylum Chlorophyta and are named for their green chloroplast which are similar in composition to the chloroplasts found in land plants.
- **Red algae** form the phylum Rhodophyta with approximately 500 genera and 600 species. Found in warm coastal waters and in water as deep as 260 m (850 ft), red alg species adapt to varied water depths by having different proportions of pigments.
- **Golden-brown algae, brown algae**, and diatoms form the large and complex phyl Heterokontophyta, with organisms ranging in size from a fraction of a millimeter to mo than 100 m (300 ft) long.
- **Cyanobacteria** are prokaryotes–single-celled organisms with characteristics that cau biologists to debate whether they are really algae or bacteria. Cyanobacteria are foun nearly everywhere, occurring in typical aquatic and terrestrial habitats as well as in suc extreme sites as hot springs with temperatures as high as 71° C (160° F) and crevices desert rocks. C

Importance

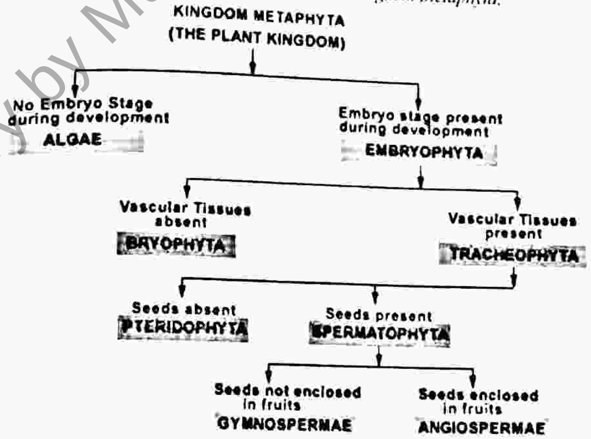
What makes Algae so important is the fact that is this single plant produces more oxyg on the Planet Earth than all the other plant species put together. It is also very resilient as you ca find Algae growing in the coldest, dark places to the most humid and wet conditions on the Ear Their rapid growth and production make them important to nearly every ecosystem that exists o earth.

Kingdom Plantae *(The kingdom Metaphyta)*

The kingdom Metaphyta (or the plant kingdom in its true sense) includes all the eukaryotic, multicellular, photosynthetic plants found in this biosphere. It consists of three major groups of plants algae, bryophytes and tracheophytes. The group algae *include* primarily aquatic or semi aquatic multicellular forms which do not possess an embryo stage.

Bryophytes are primarily terrestrial non-vascular plants, but require water for reproduction. **Tracheophytes** are land plants with vascular tissues. Both bryophytes and tracheophytes possess an embryo stage and hence, collectively described under *Embroyphyta*. Tracheophytes include the pteridophytes, gymnosperms and angiosperms.

Following are the major groups of plants placed under the Kingdom Metaphyta:



Bryophytes

Bryophytes are a group of small, simple, green, land dwelling plants of which a few are aquatic, thriving best in damp, shaded and humid localities.

They comprise Hornworts (*Anthocerotopsida*), Liverworts (*Hepaticopsida*), and Mosses (*Bryopsida*). There are about 16, 000 bryophyte species in the world, which are found on every continent, including Antarctica (Troitsky *et al.*, 2007).

1. The Plant body is a gametophyte. They grow in areas which are in between the aquatic and terrestrial habitats i.e. amphibious zone and hence known as amphibious plants.
2. They have thalloid or leafy multi cellular green plant body.
3. The smallest form is microscopic (e.g. Zoopsis). The largest genus recorded so far is an Australian Dawsonia which is about 70 cms in length.
4. The dominant plant body is gametophyte (n) which is independent.
5. The plant body lacks true roots, stem or leaves.

6. Rhizoids - (root like structure) serve the function of roots.
7. The plants are green and possess chloroplasts.
8. They show autotrophic mode of nutrition.
9. Vascular tissues are completely absent.
10. Sexual reproduction is oogamous.
11. Sex organs are multi cellular and jacketed.
12. Male reproductive organ is known as antheridium. It is a club shaped structure being borne by a narrow stalk. It produces biflagellate and motile male gametes or antherozoids.
13. The female sex organ is known as archegonium. It is a flask shaped structure having a swollen base and a narrow neck.
14. Water is essential for fertilization.
15. The diploid zygote undergoes repeated divisions to form a multi cellular sporophyte.
16. Sporophyte is dependent on the gametophyte for nutrition.
16. Sporophyte generally consists of foot, seta and capsule. It produces haploid spores
17. (homospores).
18. Spores on germination give rise to gametophyte plant.
19. Gametophyte and sporophyte differ in form which alternate with each other, thus heterologous alternation of generation is seen in Bryophytes.

Tracheophytes *(Vascular plants)*

Pteridophytes and spermatophytes are the vascular plants that have a circulatory system. A word for them is "Tracheophytes".

Tracheophytes include the true land plants or vascular plants. The adult plant body is a sporophyte and shows definite root, stem and leaves. Vascular tissues xylem and phloem are present for the translocation of water and food respectively. Gametophytic phase is short lived. It may be parasitic on the sporophyte or independent.

Tracheophytes include threse major groups of plants, namely;

- **Pteridophytes:** Vascular plants which do not produce seeds
- **Spermatophytes:** The spermatophytes *(Also called seed plants or Phanerogams)* comprise those plants that reproduces by means of seeds not spores.

Spermatophytes are divided into gymnosperms and angiosperms.

- **Gymnosperms:** Vascular plants which produce seeds but not fruits
- **Angiosperms:** Vascular plants which produce seeds enclosed in fruits

The Pteridophytes

The Pteridophyta Divsion contains ferns. Ferns are plants with leaves, roots, and stems, but they do not have flowers like most plants. Ferns have special stems, called rhizomes, which grow sideways at the surface or underground. Many leaves grow from rhizomes and make fern colonies. Fern leaves are called fronds. Fronds have a petiole (*leaf stalk*) and blade (*main part of leaf*). Each leaf has smaller leaflets called pinnae. Instead of flowers, ferns have sori, which grow directly on leaves. Sori make spores, which travel by wind, water, or animal to new locations where new fern colonies can begin. Since they spread by spores, ferns do not have flowers, pollen, fruits, or seeds.

Gymnosperms

Gymnosperms are plants that have seeds but no flowers. The seeds of these plants are on cones or in cups. Most gymnosperms are evergreen. Gymnosperms include conifers, cycads and the ginkgo.

- **Conifers** like the spruce, cedar and pine tree are **gymnosperms** and have seeds on cones. Most *Coniferous* trees are evergreen and are specially adapted to survive in areas with lots of snow
- **Cycads** were common plants about 250 million years ago. Today there are about 150 species of cycads. They grow in the tropics and subtropics. Cycads look like palms, but they aren't.
- **Ginkgophytes** There used to be lots of these gymnosperms. Today there is only one species left, the ginkgo biloba. It is native to China, but it has been transplanted and cultivated in other areas. It is thought to be extinct in the wild. The ginkgo biloba has large fan-like leaves that fall off in the winter.

Angiosperms

Angiosperms represent the most advanced group of vascular plants. They are commonly called 'Flowering plants'. They exceed all other major groups of living plants in number and diversity. Angiosperms grow in almost every kind of habitat. They occur in very high altitudes, even in Antarctica, in deserts, in shallow waters and even on other plants as parasites.

The adult plant body of an Angiosperm is a sporophyte with a well-defined *root, stem* **and leaves**. The root may be a taproot or fibrous root. The stem may soft and green (herbaceous) or hard and woody. The leaves may be simple or compound.

Summary:

Gymnosperms are woody trees with cone like appearance. They bear no flowers, no fruits but bear seeds. The seeds are naked as they are not covered by the fruit wall.

Examples: Pinus, Cycas and Cedrus trees

Angiosperm consists of herbs, shrubs and trees.

The ovules are located within the ovary, so seeds are found enclosed within the fruit wall

Eg: coconut, orchid

Similarities are

- In both case sporophyte is independent and it gets differentiated into root, stem and leaves
- Reproductive structures are special organs formed for that purpose alone
- The male gametes are not ciliated generally and are transferred to the egg by siphonogamy
- In both cases the megaspore is retained within the megasporangium and seeds are formed
- Secondary thickening takes place in both groups

Differences

	Gymnosperms	Angiosperms
1	In gymnosperms the reproductive structures are cones which are unisexual	In Angiosperms, the flowers are the reproductive organs and they may be both unisexual and bisexual.
2	The ovules are exposed, i.e., they are not located in the ovary	The ovules are enclosed in the ovary
3	After fertilization, the ovules develop into naked seeds	After fertilization, the ovules develop into seeds inside the fruit.
4	Fertlization is simple	Fertlization is double
5	Endosperm is haploid	Endosperm is triploid

6	In gymnosperms the pollination is by wind alone	In angiosperms, different agents are involved in pollination
7	In gymnosperms, generally the xylem contains only tracheids. Vessels are absent	Angiosperms vessels are always are present
8	The phloem has no companion cells	Companion cells are present

Major Groups *of* Angiosperms

Angiosperms are divided into two natural groups called monocotyledons (*or monocots*) and dicotyledons (*or dicots*). The following table summarises the differences between monocots and dicots

	Dicotyledons (*or dicots*).	**Monocotyledons** (*or Monocots*)
Embryo:	The dicotyledons embryo has two cotyledons.	Monocotyledons have one cotyledon.
Leaf venation:	Leaf veins are reticulated (*branched*).	Leaf veins are parallel.
Flowers:	Petals in multiples of four or five. May bear fruit (if tree)	Multiples of three
Secondary growth:	Often present	Absent
Stem and vascular system:	Bundles of vascular tissue arranged in a ring. The vascular system is divided into a cortex and stele.	Bundles of vascular tissue scattered throughout the stem with no particular arrangement, and has no cortex.
Pollen:	Pollen with three furrows or pores	Pollen with a single furrow or pore
Examples:	Legumes (*pea, beans, lentils, peanuts*) daisies, mint, lettuce, tomato, oak, tree, etc.	Grains, (*wheat, corn, rice, millet*) lilies, daffodils, sugarcane, banana, palm, ginger, onions, bamboo, sugar, cone, palm tree, banana tree, grass
Root Pattern:	Taproot system	Fibrous roots
Presence or absence of wood:	Both herbaceous and woody	Herbaceous
No of seed leaves:	2 seed leaves	1 seed leaf

***Q:* Are pine trees monocots or dicots?**

Pines are *conifers*, and are neither monocots nor dicots. Only flowering plants are considered to be members of these two classes

***Q:* Do all dicots produce flowers?**

All dicots and monocots are flowering plants, and so are descended from flower-producing plants. However, the flowers are not always large and showy the way we expect flowers to be. Oaks, maples, and sycamore are all dicot trees, but they do not produce obvious flowers. Grasses and cattails are monocots whose flowers are often overlooked because they do not have sepals or petals.

There are also some flowering plants which flower only rarely. Duckweeds are tiny flowering plants which reproduce and spread primarily by *vegetative growth*; they grow by cellular division, and the resulting cluster will then break apart.

***Q:* If monocots don't have wood, then what supports palm trees?**

Palms rely on overlapping leaf bases, thickened enlarged cells, and prop roots to stay up. This strategy is also used by cycads and tree ferns.

Life Styles in Angiosperms

Angiosperms exhibit a great diversity in form, size, structure and life span of the plant body. Based on the duration of life span, angiosperms are classified into annuals, biennials and perennials.

- **Annuals:** Plants which complete their life cycle in one season. *e.g.* Sunflower, Mustard, Pea, Bean, Rice, Maize
- **Biennials** are plants that complete their life cycle in two years. In the second year of their life span they produce flowers, fruits and seeds. *e.g.* Carrot, Radish, Beetroot, Turnip.
- **Perennials** plants that live for more than two years. Every year they produce flowers, fruits and seeds. *e.g.* Mango, Rose, Dahlia, Bamboo.

Plant Body

Unlike animals, plants only have 3 organs

Basic Plant Parts:

1. **Root** - absorbing/anchoring organ (*sometimes storage*)
2. **Stem** - supportive, conductive organ (*sometimes storage*)
3. **Leaf** - photosynthetic organ (*sometimes modified*)

Roots are the principal water-absorbing organs of a plant. They are present on essentially all vascular plants

There are three primary functions of roots:

(1) To anchor the plant to a substrate
(2) To absorb water and dissolved minerals, *and*
(3) To store food reserves

Animal Kingdom

The animal kingdom includes eukaryotic multicellular organisms which exhib heterotrophic nutrition. They are commonly known as animals and differ characteristically from the other major groups of plants, in their capacity to be able to move.

Animals contribute to about a million living species that occur in all types of habita Animals exhibit a great deal of variation in their form, size and life styles.

Animal Diversity

The diverse appearance of animals is mostly superficial: the bewildering variety of known forms, some truly bizarre, can be assorted among a mere half-dozen basic body plans. These plans are established during the embryonic stages of development and limit the size and complexity of the animals. Symmetry, number and relative development of tissue layers, presence and nature of body cavities, and several aspects of early development define these fundamental modes of organization.

The following is a list of the animal groups regarded as major phyla

1. **Porifera** (CSS 2013) This Phylum includes animals known as sponges. They have bodies full of pores and channels that allow water to circulate through them. Sponges lack nervous, digestive or circulatory systems Most sponges have no body symmetry, although some have radial symmetry
2. **Cnidarian** This Phylum includes corals, sea anemones, jellyfish and hydras. Most are found in salt water with a smaller number living in freshwater. There are two body types of cnidarian: a sessile polyp and a free - floating medusa.
3. **Platyhelminthes:** This Phylum includes worms called "flatworms" such as planaria, tapeworms and flukes. Flatworms may live freely or paras itically, although most species are parasites, particularly of vertebrates.
4. **Annelida:** This Phylum includes segmented worms such as earthworms, leeches, and polychaetes. They have a complete digestive system (with separate openings for the mouth and anus), and a separate nerve center (called a ganglion) Polychaetes (meaning "many hairs") live in marine environments
5. **Mollusca** This Phylum includes clams, snails, squid and their relatives. It is the most diverse group of lophotrochozoans, both in numbers of species and in environments they occupy.
6. **Nematoda** This Phylum includes worms called "roundworms". Nematodes and their relatives are abundant and diverse, many are microscopic. The largest known nematode, which reaches a length of 9 meters (29.5 ft.!) is a parasite in the placentas of sperm whales
7. **Arthropoda:** This Phylum includes insects, crustaceans, centipedes, millipedes, spiders, scorpions, mites and ticks, and their relatives. Arthropods are the most diverse group of animals with respect to number of species and they are found in almost every environment on earth. Approximately 75 % o f the known animal species are arthropods
8. **Echinodermata** This Phylum includes sea stars sea urchins, sea cucumbers, sand dollars, brittle stars, and their relatives. Echinoderms have a bilaterally symmetrical, ciliated larva. They have a unique hydrostatic skeleton known as water vascular system
9. **Chordata** This Phylum includes the well - known vertebrates and a few other small marine organisms such as lancelets and tunicates Vertebrates (mammals, birds, fishes, reptiles, amphibians) are familiar to most people.

Vertebrates *and* invertebrates (CSS 2010)

Almost all animals fall into one of two groups. Adult vertebrates have a spinal column, or backbone, running the length of the body; invertebrates do not. Vertebrates are often larger and have more complex bodies than invertebrates. However, there are many more invertebrates than vertebrates. The main difference between vertebrates and invertebrates is that invertebrates do not have a backbone or a spinal column. Examples of vertebrates include humans, birds and snakes while examples of invertebrates include insects and flatworms

Difference *between* vertebrates *and* invertebrates

	Invertebrates	**Vertebrates**
About:	Animals without a backbone	Animals with an internal skeleton made of bone are called vertebrates.
Kingdom:	Animalia	Animalia
Physical Characteristics:	Multicellular; no back bone; no cell walls; reproduce sexually; heterotrophic.	Well-developed internal skeleton; highly developed brain; have advanced nervous system; outer covering of protective cellular skin.
Examples:	Insects, flatworms etc.	Parrots, Humans, snakes etc
Classification:	30 phyla	Classified into five groups: fish, amphibians, reptiles, birds, and mammals.
Phylum:	Chordata	Chordata
Size:	Small and slow moving.	Big in size.
Species:	98% of animal species are invertebrates.	2% of the animal species are vertebrates.
Number of species:	2 million	57,739

Vertebrates (CSS 2010)

The Phylum Chordata has a tremendously large evolutionary potential. This potential for genetic variability is clearly seen in its geological record which extends from the Cambrian Period to the present day.

The underlying unifying characteristic of the Chordata is the presence of a notochord, as an unsegmented elastic rod situated dorsally to the alimentary canal and ventrally to a dorsal nerve chord. The notochord is the basis of the complex endoskeleton found in the higher Chordates. In addition to the notochord, gill slits and a hollow nerve chord are present.

Fish

Scientific Class Name	**Example Images**	**Example Organism Names**	**Important Characteristics**
Condrichthyes		Sea horse Shark Bass	Live entirely in water *Use their gills to obtain dissolved* Oxygen from the water *exothermic (aka ectothermic)* Bodies covered with scales *Most lay eggs (external*

			fertilization)

Amphibian (CSS 2009)

Scientific Class Name	**Example Images**	**Example Organism Names**	**Important Characteristics**
Amphibia		Frog Toad Salamander	Live part of their lives in water and part on land (use gills while tadpoles and lungs/skin as adults to breathe) *Exothermic (aka ectothermic)* *Smooth skin* Lay eggs (external fertilization)

Reptile

Scientific Class Name	**Example Images**	**Example Organism Names**	**Important Characteristics**
Reptile		Iguana Turtle Snake	Live mainly on land Breathe air *Exothermic (aka ectothermic)* *Body covered with hard plates or scales* Most lay eggs (internal fertilization)

Bird (CSS 2010)

Scientific Class Name	**Example Images**	**Example Organism Names**	**Important Characteristics**
Aves		Owl Ostrich Robin	Live on land Breathe air Endothermic Body covered with feathers Have hollow, lightweight bones Lay eggs (internal fertilization)

General Characteristics:

- Birds are flight orientated organisms. Each part of its anatomy is modified in some way to allow it to keep its body light and energetic for flight.
- Very active metabolism. They can eat, digest, and eliminate the waste in a short amount of time. Their body temperature is rather high 102-103 degrees F. They are **endotherms**.
- They contain a four chambered heart.
- Their skeleton is constructed of light weight bones supported by an inner meshwork of bony material to give extra support while flying.
- The female loses one of its ovaries.
- They have no teeth and their beak is made of a light protein **keratin**.
- They contain feathers, also made of keratin. There are three types of feathers: down **feathers** which are used for insulation, **contour feathers** which are colorful and used for recognition, and keeping the body aerodynamic, and **quill** feathers which are used for flight. These feathers are lost periodically (molting).
- They have an extensive air sac system attached to the lungs. This reduces the weight of the bird and supplies the needed air for a fast metabolism. It also is used to dissipate the tremendous amount of heat built up from metabolism.
- They develop from the amniote egg. Bird egg shells are hardened with calcium carbonate for added protection.
- Birds that are ready to carry on life's duties upon hatching are called precotial, while those that need further development are called altricial.
- They have a well developed nervous system. Acute vision, and external ears.
- Well developed muscles. The keel a part of the sternum, allows large pectoral muscles to be attached to the skeleton.
- Their forelimbs are modifies as wings. These wings are homologous to the limbs of the reptiles, amphibians, and mammals.
- Their hind limbs are modified for various jobs based on the structure of their claws.
- Birds are an excellent indicator of the fitness of the environment. They help keep the insect population down, use rodents as a food source, help rid the environment of dead and decaying organic material, and help pollinate many types of plants.
- Many birds migrate over long distances to find suitable breeding grounds and protection from major climatic changes.

Mammal

Scientific Class Name	**Example Images**	**Example Organism Names**	**Important Characteristics**
Mammal		Human Kangaroo Whale	Most live on land Breath air Endothermic Body covered with fur or hair Young develop entirely inside mother's body (internal fertilization) Produce milk to nurse their young

- Possess hair which is made of keratin. The evolution of mammalian keratin is believed to be independent of reptilian keratin. Hair provides insulation.
- Endothermic. The majority of the heat energy is used to maintain their high body temperature.
- 4 chambered heart.
- **Mammary glands** are used to produce milk to nourish their young. Female glands are the only functional glands.
- The **diaphragm** is a muscle that separates the thoracic cavity from the abdominal cavity.
- 7 cervical vertebrae (neck bones) are present in most mammals.
- Most are viviparous though some are oviparous. An extended **gestation period** (uterine development) is common in most placental mammals.
- Teeth are imbedded in the jaw bone and come in a variety of forms.
- Well developed brain.

Chart of Placental Mammals

Order	**Characteristics**	**Examples**
Carnivora	Eats meat, all teeth are pointed	Cats and Dogs . Seals, Walrus, Weasels, and Martins
Chiroptera	Wings used for flight, diet includes insects and vegetation	Bats
Primates	Opposable thumb, plantigrade foot, usually one offspring at birth.	Man . Apes, Monkeys,Tarsiers,and Lemurs
Edentata	Lacking teeth, large claws for digging	Sloths, armadillos, South American anteater
Rodentia	2 incisors on both jaws, diastema between incisors and premolars	Rats, Mice, Squirrels, Beavers, Gophers, and Capybara
Lagmorpha	4 incisor teeth, canine teeth lacking, short stubby tails	Rabbits, Hares,Pikas
Cetacea	Fippers, opening on top of head	Dolphins,Whales,Porpoises
Proboscidea	Great size,nose and upper lip form proboscis, upper incisors are tusks,thick skin,scant hair	Elephant
Sirenia	Herbivorous, aquatic, no external ears, flippers, no hind appendages	Manatees and Dugongs
Perissodactyla	Odd-toed,hoofed forms,gall bladder lacking, herbivorous	Horses, Donkeys,Zebras,Tapirs
Artiodactyla	Even-toed, hoofed forms, herbivorous, true horns or antlers present	Cattle,Pigs,Camels,Deer,Hippopotami

Difference between Apes and Monkey (CSS 1998)

Apes are Monkeys, both belong to the family of Simian Primates which have similar origins but differ in their physical attributes and other habits.

	 Apes	 **Monkey**
Tail:	No	Yes
Diet:	Fruits, grass seeds, small invertebrates, small mammals	Fruits, leaves, insects, spiders etc.
Class:	Mammal	Mammal
Structure:	Apes' arms are longer than their legs. They use their arms to swing branch to branch. Can walk upright (two legs)	Monkeys' arms are the same length as, or shorter than, their legs. Cannot swing from branches. Move on four feet.
Brain size:	Large	Small
Order:	Primates	Primates
Demographics:	Africa and Asia but found across the world now.	Asia, Africa and South America.
Lifespan:	Can live up to 60 years	Can live up to 30 years
Habitat:	Semi terrestrial, terrestrial	Arboreal, semi terrestrial
Species:	Around 13 broad species which in turn have many species	Hundreds of known species
Family:	Hominoidea	Cercopithecidae
Tool use:	Can make and use tools for hunting brushes for catching termites and spears for hunting monkeys (*Only chimpanzees use spears*)	No tool use

Animals & Their *(Habitat)* Locations

	Animal		**Location**
1	Snow Leopard	CSS 1992	Asia *Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Russia, Tajikistan, and Uzbekistan.*
2	Peacock		Asia
3	Tiger		Asia
4	Elephant		Asia
5	Cobra	CSS 1995	Asia/Southern Africa
6	Panda	CSS 1992/1995/2010	Asia/China
7	Camel		Asia
8	Panda		Asia
9	Orangutan		Asia
10	Ibex	CSS 1992	Asia /Africa/Europe
11	Yak		Asia
12	Hyena		Africa
13	Wildebeest		Africa
14	Chimpanzee	CSS 2011	Africa (*West and Central Africa /forests of the Democratic Republic of the Congo*)
15	Lion		Africa
16	Giraffe		Africa
17	Rhinoceros	CSS 2011	Africa/ Asia
18	Vulture		Africa
19	Zebra		Africa
20	Ostrich	CSS 1995/2011	Africa
21	Hog		Africa
22	Gorilla		Africa
23	Hippopotamus		Africa
24	Elephant		Africa/Asia
25	Kiwi	CSS 1992/1995/2010	New Zealand
26	Platypus	CSS 2011	Australia
27	Bingo Dog		Australia
28	Numbat		Australia
29	Koala Bear		Australia
30	Kangaroo	CSS 1992/2010	Australia

31	Kangaroo Rat		Australia
32	Emu		Australia
33	Crocodile		Australia
34	Tasmanian Devil		Australia
35	Bat		Europe
36	Moose		Europe
37	Shetland Pony		Europe
38	Deer		Europe
39	Porcupine		Europe
40	Wolf		Europe
41	Wild Boar		Europe
42	Fox		Europe
43	Raccoon		Europe
44	Lynx		Europe
45	Bear		Europe
46	Lobster Shrimp		Ocean And Sea Animals
47	Blue Whale	CSS 1995	North Atlantic and North Pacific, Southern Ocean , Indian Ocean and South Pacific Ocean.
48	Octopus / Squid		Ocean And Sea Animals
49	Shark	CSS 1995	Ocean And Sea Animals / *Sharks are found in all seas and are common to depths of 2,000 metres (6,600 ft).*
50	Seagull		Ocean And Sea Animals
51	Walrus		Ocean And Sea Animals
52	Barracuda		Ocean And Sea Animals
53	Dolphin /Porpoise	CSS 1995	Ocean And Sea Animals
54	Blind Dolphin	CSS 2010	The Indus River *dolphin* was apparently formerly common and distributed throughout 3,500 km (2200 mi) *of* the Indus River system in *Pakistan*
55	Turtle Tortoise	CSS 1995	Ocean And Sea Animals
56	Oyster		Ocean And Sea Animals
57	Eel		Ocean And Sea Animals
58	Pelican		Ocean And Sea Animals
59	Anaconda		South America
60	Howling Monkey		South America
61	Rattlesnakes	CSS 2011	South America
62	Pirahna		South America
63	Macaw		South America
64	Llama	CSS 1992	South America
65	Tree Frog		South America
66	Jaguar		South America
67	Anteater		South America
68	Sloth		South America
69	Antelope		North America

70	Rattlesnake		North America
71	Great Bear		North America
72	Bald Eagle		North America
73	Badger		North America
74	Frog		North America
75	Mink		North America
76	Bison		North America
77	Cougar		North America
78	Wolf		North America
79	Alligator	CSS 1995	North America
80	Lemming		North Pole, South Pole And Antarctica
81	Penguin	CSS 1992/1995/2010	North Pole, South Pole And Antarctica
82	Polar Bear		North Pole, South Pole And Antarctica
83	Musk Ox		North Pole, South Pole And Antarctica
84	Arctic Fox		North Pole, South Pole And Antarctica
85	Arctic Seal		North Pole, South Pole And Antarctica

Micro-Organism

Microorganisms are very tiny one-celled organisms, viruses, fungi, and bacteria, and are found everywhere in the world. They are found in all living things, plants and animal. There are more microorganisms on and inside your body than there are cells that make up your entire body. Microorganisms can live in the air, on land, and in fresh or salt water environments. Some of them, pathogens, can be harmful and causes diseases, but there are some microorganisms that are needed for living things to survive.

How are microorganisms identified?

Microorganisms are put into groups, but a lot of microorganisms can belong to more than one group. One way that microorganisms are grouped is by the temperature in their environment. Another way to organize microorganisms is by placing them in either the prokaryot or eukaryot group.

How do microorganisms reproduce??

Thermophiles reproduce either by sexual or asexual reproduction. Sexual reproduction requires a male and female organism, but asexual reproduction happens by cell division, mitosis. Thermophilic fungi reproduce by producing male and female spores that come in contact with each other to produce a new organism

What do microorganisms do?

Microorganisms also are responsible for building fertile soil for plants to grow in. Microbes stick to the roots of plants and decompose dead organic matter into food for the plant to absorb. The plants that live and grow because of the microorganisms that live on them make a home for other animals to live in. Some microorganisms make people, animals, and plants sick, but others make people well and kill the bacteria on plants that make them sick. Drug companies that make medicines use hundreds of different microorganisms to make medicines that will help cure diseases. Human waste products are broken down into safer particles by some microorganism

There are *4 types* of *microbes* (*micro-organisms*) that *cause disease;. Viruses; Bacteria; Fungi;*

Protozoa (*also known* as *protoctista*).

Protozoa

The name protozoon means "first animals." As the principal hunters and grazers of the microbial world, protozoa play a key role in maintaining the balance of bacterial, algal, and other microbial life. They also are themselves an important food source for larger creatures and the basis of many food chains.

Protozoa have been found in almost every kind of soil environment from peat bogs to arid desert sands. They teem in the deep sea as well as near the surface of waters, and can be found even in frigid Arctic and Antarctic waters. The four main subgroups of protozoa are the ciliates, the flagellates, the sarcodina, and the apicomplexans

The vast majority of protozoa do us no harm. But, yes, there are a few that cause disease One type of amoeba can live in human intestines. It feeds on red blood cells and causes a disease known as dysentery The parasitic protozoan *Cryptosporidium parvum* sickened around 400,000 people in Milwaukee in 1993 when it got into the tap water. Perhaps the best-known protozoal menace is *Plasmodium* the parasite that causes malaria. This terrible disease leads to about 800,000 deaths each year worldwide.

Bacteria

Bacteria are minute microscopic prokaryotes. They are unicellular organisms, which are usually identified by their specific activities, more than their general organisation

Occurrence

Bacteria are omnipresent, occurring in all environments. They occur in water, in air, in soil, and in or on the bodies of living organisms. There are bacteria which occur in hot springs as well as in extreme cold temperature.

Size

The average size of bacterial cell ranges from 1 mm to 10 mm in length and about 0.7 mm to 1.5 mm in width. The largest bacterium is Beggiatoa mirabilis. It is a few centimeters long and about 30-40 m in diameter.

Shape

The bacteria generally exhibit a fairly constant shape and form. However, some of them are capable of changing their body shape and size in accordance with the environmental needs. Such bacteria are called *pleomorphic.*

Different Forms of Bacteria

- **Cocci** (Singular Coccus)
- **Bacillus** (Rl- bacilli) *they are straight, cylindrical, rod shaped bacteria*
- **Spirillum** *These bacteria are spirally coiled like a corkscrew*
- **Vibrio** *These are elongated, C shaped or comma shaped bacteria*

Bacterial Cell Structure

A typical bacterial cell shows the following structural features:

Capsule and Slime Layers

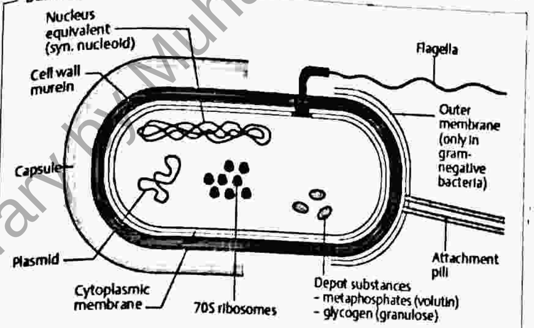
A lose gelatinous sheath called *slime layer* is usually deposited around the bacterial cell wall. It is usually composed of polysaccharides. In some bacteria, the slime layer becomes thick due to the presence of some nitrogen compounds and forms a capsule. A capsule is particularly common in the parasitic forms.

Cell Wall

It is the outer tough covering around the cell, which provides specific shape and protection to the bacterium. It prevents the cell from swelling and bursting due to osmotic changes. It is composed of a polysaccharide called murein or peptidoglycan. It consists of polysaccharide cross linked with short amino acid chains.

The cell wall of gram positive bacteria is much thicker and contains less lipids compared to that of Gram negative bacteria. The cell wall can be dissolved by the enzyme *lysozyme*.

Basic Bacterial Cell Structure



All bacteria have the same basic structure (not to scale).

Plasma Membrane

It is a thin, elastic, selectively permeable membrane found internal to the cell wall. It is composed of phospholipids, proteins and polysaccharides. The plasma membrane is the site of most of the metabolic pathways. Certain structures are found associated with plasma membrane.

Mesosomes

These are invaginations formed by the plasma membrane. They are spherical or elongated structures which bring about a functional compartmentalization of the cell. They have significant roles in cell division and replication. They are more common in Gram positive bacteria.

Flagella

These are long, slender thread-like structures, which help in locomotion. A bacterial cell may have one to many flagella. The flagella are entirely composed of a protein called flagellin. The basal body of each flagellum is directly attached to the plasma membrane. It is not covered by any sheath.

Pili *or* Fimbriae

These are extremely minute hair-like structures found mostly in male cells. They are composed of protein subunits called pilin. They take part in the formation of conjugation tube. They are therefore called sex pili.

Cytoplasm

It is a semi-fluid ground substance enclosed by the plasma membrane. It appears granular due to the presence of large number (as many as 20,000) ribosomes. The ribosomes may occur singly or in clusters called *polyribosomes*. Membrane-*bound cell organelles like mitochondria, lysosomes, golgi complex, vacuoles and endoplasmic reticulum are absent.*

Nucleoid *(or Bacterial Chromosome)*

Since the bacterial cell is prokaryotic, a true nucleus is absent. The nuclear material is represented by DNA which is not associated with histones. It is identified as a *nucleoid* or *bacterial chromosome.* It is a circular ring. It is attached at a point to the plasma membrane.

Plasmids

Apart from the nucleoid, certain bacterial cells contain additional rings of DNA called plasmids. The plasmid DNA replicates independently. It has certain genes like fertility factor (F-factor), resistance factor (R-factor), nitrogen fixing genes (Nif-genes). Some plasmids may temporarily become associated with nucleoid DNA and are known as episomes.

Nutrition in Bacteria

Bacteria exhibit different modes of nutrition. On this basis, broadly two types of bacteria can be recognised *autotrophic bacteria* and *heterotrophic bacteria.*

Autotrophic Bacteria

These are bacteria which are able to synthesize their own organic food from inorganic substances. They use carbon dioxide for obtaining carbon and utilise hydrogen sulphide (H_2S) or ammonia (NH_3) or hydrogen (H_2) as the source of hydrogen to reduce carbon. These bacteria can be distinguished further into two types as follows:

- The **photoautotrophic bacteria** possess photosynthetic pigments in membrane bound lamellae (or thylakoids) and utilise solar energy. The bacterial photosynthesis is different from that of green plants since here water is not used as a hydrogen donor. Hence oxygen is not released as a byproduct. For this reason, the process is described as anoxygenic photosynthesis.

$$CO_2 + H_2S \xrightarrow{\text{light energy}} \text{sugars} + \text{sulphur} + \text{water}$$

These are bacteria which manufacture organic compounds from inorganic raw materials utilising energy liberated from the oxidation of inorganic substances. Following are the common types of chemo autotrophic bacteria

Nitrifying bacteria which derive energy by oxidizing ammonia into nitrates. Eg
Nitrosomonas, Nitrobacter

$$NH_4^+ + 2O_2 \rightarrow NO_2 + 2H_2O + \text{energy}$$

Sulphur bacteria which derive energy by oxidising hydrogen sulphide to sulphur. Eg
Thiobacillus, Beggiatoa.

$$2H_2S + O_2 \rightarrow 2S + 2H_2O + \text{energy}$$

Iron Bacteria which derive energy by oxidising ferrous ions into ferric form. Eg
Ferrobacillus, Gallionella

$$4Feco_3 + 6H_2O + o_2 \rightarrow 4Fe(OH)_3 + 4CO_2 + \text{energy}$$

Heterotrophic Bacteria

These are bacteria which are unable to manufacture their own organic food and hence are dependent on external source. These bacteria can be distinguished into three groups as follows

- **Parasitic Bacteria** These are bacteria which occur in the body of animals and plants, obtaining their organic food from there. Most of these bacteria are *pathogenic*, causing serious diseases in the host organisms either by exploiting them or by releasing poisonous secretions called toxins.
- The Aerobic Breakdown of organic matter is called as decay or decomposition. It is usually complete and not accompanied by the release of foul gases. Anaerobic breakdown of organic matter is called fermentation. It is usually incomplete and is always accompanied by the release of foul gases. Anaerobic breakdown of proteins is called putrifaction.
- **Saprophytic Bacteria:** These bacteria obtain their nutritional requirements from dead organic matter.

Bacterial Reproduction

Most bacteria reproduce by binary fission. During binary fission, the single DNA molecule replicates and both copies attach to the cell membrane. The cell membrane begins to grow between the two DNA molecules. Once the bacterium just about doubles its original size, the cell membrane begins to pinch inward A cell wall then forms between the two DNA molecules dividing the original cell into two identical daughter cells.

Bacteria: Friend or Foe?

Bacteria are all around us and most people only consider these prokaryotic organisms to be disease causing parasites. While it is true that bacteria are responsible for a large number of human diseases, they also make it possible for certain elements such as carbon, nitrogen, and oxygen to be returned to the atmosphere

The decision as to whether bacteria are friend or foe becomes more difficult when both the positive and negative aspects of the relationship between humans and bacteria are considered.

Harmful bacteria

1. Certain bacteria act as pathogens and cause tetanus, typhoid fever, pneumonia, syphilis, cholera, food-borne illness and tuberculosis.
2. Streptococcus bacteria may cause small infections like strep throat and some serious diseases like pneumonia. Certain streptococci may be fatal.
3. Bacteria that usually live harmlessly in the body may cause infections when a person's resistance to disease is reduced in conditions such as AIDS (*Acquired Immune Deficiency Syndrome*).
4. Not all stomach bacteria are beneficial, some of the stomach bacteria enter the body through the mouth, and they can survive in the acidic conditions in the stomach and can cause serious diseases and can be fatal
5. Campylobacter is a group of bacteria that can create illnesses in humans and is a common cause of food poisoning. Harmful bacteria in food cause botulism, which can cause paralysis or even death if even one millionth of the bacterium is ingested.
6. Yersinia pestis or bubonic plague is a rod-shaped type of bacterium which is well known for its harmful nature. Bacteria-carrying fleas found on animals such as rats and mice transmit the bacteria that are believed to have caused the deaths of millions of people in human history.

Useful Bacteria

1. Lactobacillus Acidophilus: These are the most friendly bacteria where lactobacillus is the genus name and acidophilus is the particular strain. They are naturally present in dairy

products and also added in dietary supplements for better results.

2. Tobacillus Acidophilus: They belong to the genus Lactobacillus and are acid lovin bacteria. These beneficial bacteria. found in buttermilk. yogurt, sour cream and froz desserts, convert sugar and carbohydrates into lactic acid and so, are called lactic ac bacteria. By lowering the pH and reducing the risk of growth of other organisms in the food through this process, they generate the fermented taste. This process is beneficial f people, as it prevents the gastrointestinal infections.
3. Cyanocobalamin: These bacteria help in the production of vitamin B12 during th process of digestion. Probiotics are responsible for the overall digestive health, as th break down the complex components of the food, so that, they can be easily absorbed i the blood.
4. Acidophilus Bifidus: Acidophilus Bifidus reduce cholesterol levels and prevent th growth of hostile yeasts like Candida albicans. The acidophilus bifidus bacteria cleans the blood stream by removing the toxins. Thus, they enhance the immune system.
5 Streptomyces: Streptomyces are used in manufacturing of antibiotics.
6. Rhizobium: These play an important role in nitrogen fixation

Fungi

The kingdom Mycota includes exclusively the fungi. The fungi are a group of organism which has a plant body called *thallus* that may be unicellular or multicellular. They ar *achlorophyllous* and *non-vascular*

Fungi represent another major group of decomposers along with some of th heterotrophic monerans and protistans. Many of them occur as parasites causing diseases an damage to the host. Some of them are beneficial to man and are widely used in food and chemi industries. The study of fungi has emerged into a separate branch of biology called *mycology*

For a long time fungi were classified as plants, mainly because of their similar lifestyles. Plant and fung both are seen to grow in soil and are sessile (permanently attached; not moving). Plant and fungi cells both have a cell wall, while cells from the animal kingdom don't. Fungi are thought to ha diverged from the plant and animal kingdoms about one billion years ago.

Fungi occur in almost every habitat where organic matter is available. They can grow regions with total darkness since they are non-photosynthetic organisms. The most comm habitat of fungi is, wet soil rich in humus.

The body of a fungus can be described as a *thallus* since it is not differentiated into ro system and leaves. The thallus may be unicellular as in Synchariun and Saccharomyces (yea or multicellular as in most other examples. In most of the multicellular forms, the thallus consi of long, tubular, branched filament called hyphae (singular-*hypha*). A collection of hyphae called *mycelium*. The entire mycelium develops from a single spore. In the unicellular fun yeast, several cells may become attached to form a chain called *pseudomycelium*.

The individual fungal cells are bound by definite cell wall made up of chitin or cellulo or both. Chitin also called as fungal cellulose, is normally found in association with oth compounds like proteins and lipids. The cell wall encloses protoplasts which are differentia into plasma membrane, cytoplasm, nucleus and vacuoles. Except plastids, all other cell organel are present. The reserve food is glycogen or oil droplets.

Fungi exhibit three major modes of reproduction - vegetative, asexual and sexual.

Fungi Diseases in Human

Fungi can cause fungal skin or vaginal infections, oral thrush, allergies, severe syste

infections like invasive candidiasis or aspergillosis, and even cancer.

Mushrooms, Rust, smut, morrels, truffles, yeast lichens, penicillin and bread mold are all examples of fungi.

Uses of Fungi

- **Fungi as a food or used in food preparation:** Humans have been eating fungi since before we started walking on our hind legs. Today we eat an enormous variety of edible fungi, including truffles, mushrooms, quorn, shitake and hundreds others. We also use fungi, e.g. yeast, in food manufacturing. Yeast is needed for the fermentation of wine, beers and other alcoholic drinks. We add yeast to dough to make the bread rise when we bake it.
- **Fungi used in industry and agriculture:** Fungi are used in the production of ethanol. They are used extensively to produce industrial chemicals, such as citric acid, gluconic acid, malic acid, and biological detergents. The production of many deliberately faded garments would be much more difficult without using fungi. They are used in bioremediation - the detoxification of polluted water or soil. *Fungi are also used in agriculture for pest control and to protect crops from diseases.*
- **Fungi used in medicine**
    - **Antibiotics** - Many types of antibiotics come from fungi, such as penicillin *(Penicillium chrysogenum)*, cephalosporin *(Acremonium)*, and griseofulvin *(Penicillium griseofulvin)*. Penicillin works by destroying the wall of a bacterial cell. Fungal antibiotics are extensively used for treating tuberculosis, syphilis, and leprosy, to name but a few diseases.
    - **Chemotherapy** - Antibacterial chemotherapy uses fungi. Lentilan, a drug used in cancer treatment, is sourced from the shiitake mushroom.
    - **Immunosuppressant** - Cyclosporin is a medication that transplant patients take to suppress their immune system. It is produced by the fungus *Beauveria nivea* and significantly lowers the risk of transplanted organ refection. Many successful transplant procedures could not have occurred without this drug.
    - Laboratory studies indicate that *Agaricus blazei* may stimulate the human immune system and could have major implications for human health - especially in the treatment of many cancers.
    - US researchers reported that a rapid production of therapeutic human drugs using modified mushrooms may help mount a quicker response to various public health problems.
    - The reishi mushroom *(Ganoderma lucidum)* and green tea may both enhance the body's immune functions and hold the potential for treatment and prevention of many types of cancer, scientists from Pharmanex BJ Clinical Pharmacology Center in Beijing reported.
    - Extracts of the mushroom *Phellinus linteus* may halt breast cancer growth, according to scientists from the Methodist Research Institute in Indianapolis, USA.
- **Traditional Chinese Medicine** includes several types of mushrooms, such as *Agaricus*, *Ganoderma*, and *Cordyceps* among its various therapies.

Viruses (CSS 1994)

Viruses are tiny organisms that may lead to mild to severe illnesses in humans, animals and plants. This may include flu or a cold to something more life threatening like HIV/AIDS.

How Big Are Viruses?

The virus particles are 100 times smaller than a single bacteria cell. The bacterial cell alone is more than 10 times smaller than a human cell and a human cell is 10 times smaller than the diameter of a single human hair.

Are Viruses Alive?

Viruses by themselves are not alive. They cannot grow or multiply on their own and need to enter a human or animal cell and take over the cell to help them multiply. These viruses may also infect bacterial cells.

The virus particle or the visions attack the cell and take over its machinery to carry out their own life processes of multiplication and growth. An infected cell will produce viral particles instead of its usual products.

Structure of a Virus

A virion (virus particle) has three main parts:

- **Nucleic acid** – this is the core of the virus with the DNA or RNA (deoxyribonucleic acid and ribonucleic acid respectively). The DNA or RNA holds all of the information for the virus and that makes it unique and helps it multiply.
- **Protein Coat** (capsid) – This is covering over the nucleic acid that protects it.
- **Lipid membrane** (envelope) – this covers the capsid. Many viruses do not have this envelope and are called naked viruses.

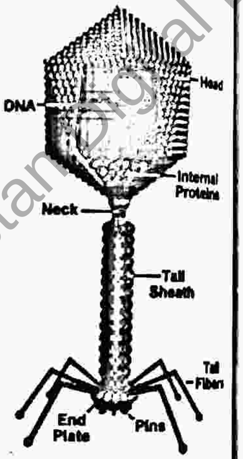
Receptors

Viruses are not simply taken into cells. They must first attach to a receptor on the cell surface. Each virus has its specific receptor, usually a vital component of the cell surface. It is the distribution of these receptor molecules on host cells that determines the cell-preference of viruses. For example, the cold and flu virus prefers the mucus lining cells of the lungs and the airways.

How Do Virus Infect?

Viruses do not have the chemical machinery needed to survive on their own. They, thus seek out host cells in which they can multiply. These viruses enter the body from the environment or other individuals from soil to water to air via nose, mouth, or any breaks in the skin and seek a cell to infect.

A cold or flu virus for example will target cells that line the respiratory (*i.e.* the lungs) or digestive (*i.e.* the stomach) tracts. The HIV (human immunodeficiency virus) that causes AIDS attacks the T-cells (*a type of white blood cell that fights infection and disease*) of the immune system.



Life Cycle of a Basic Virus

There are a few basic steps that all infecting viruses follow and these are called the lytic cycle. These include:

1. A virus particle attaches to a host cell. This is called the process of adsorption

2. The particle injects its DNA or RNA into the host cell called entry.
3. The invading DNA or RNA takes over the cell and recruits the host's enzymes
4. The cellular enzymes start making new virus particles called replication
5. The particles of the virus created by the cell come together to form new viruses. This is called assembly
6. The newly formed viruses kill the cell so that they may break free and search for a new host cell. This is called release.

Difference *between* Virus *and* Bacteria

Bacteria (singular: *bacterium*) are unicellular microorganisms. They are typically a few micrometers long and have many shapes including curved rods, spheres, rods, and spirals.

A virus (from the Latin noun *virus*, meaning toxin or poison) is a sub-microscopic particle (ranging in size from 20–300 nm) that can infect the cells of a biological organism.

	Bacteria	Virus
Ribosomes:	Present	Absent
Living attributes:	Living organism	Opinions differ on whether viruses are a form of life or organic structures that interact with living organisms.
Number of cells:	Unicellular; one cell	No cells; not living
Structures:	DNA and RNA floating freely in cytoplasm. Has cell wall and cell membrane.	DNA or RNA enclosed inside a coat of protein.
Treatment:	Antibiotics	Vaccines prevent the spread and antiviral medications help to slow reproduction but cannot stop it completely.
Enzymes:	Yes	Yes, in some
Nucleus:	No	No
Virulence:	Yes	Yes
Infection:	Localized	Systemic
Benefits:	Some bacteria are beneficial (e.g. certain bacteria are required in the gut)	Viruses are not beneficial. However, a particular virus may be able to destroy brain tumors (see references). Viruses can be useful in genetic engineering.
Reproduction:	Fission- a form of asexual reproduction	Invades a host cell and takes over the cell causing it to make copies of the viral DNA/RNA. Destroys the host cell releasing new viruses.

Size:	Larger (1000nm)	Smaller (20 - 400nm)
Cell wall:	Peptidoglycan/Lipopolysaccharide	No cell wall. Protein coa present instead.

Smaller than Viruses

There are things out there even smaller than viruses. The two that scientists ha discovered are called *prions* and *viroids*. A prion is just a protein. Prions are proteins that invade cells and somehow direct their own duplication. making more of the isolated prote Viroids are a little different in that they are just RNA. Scientists have even discovered that th are responsible for some diseases

- **Prion**-A disease-causing agent that is neither bacterial nor fungal nor viral and conta no genetic material. A prion is a protein that occurs normally in a harmless form. folding into an aberrant shape. the normal prion turns into a rogue agent. It then co other normal prions to become rogue prions
- **Viroid**-the smallest of viruses; a plant virus with its RNA arranged in a circula chromosome without a protein coat

Ecology and Ecosystem

Ecology

Ecology, the study of the relationship of plants and animals to their physical an biological environment. The physical environment includes light and heat or solar radiation moisture, wind, oxygen, carbon dioxide, nutrients in soil, water, and atmosphere. The biologic environment includes organisms of the same kind as well as other plants and animals. The term *ecology* was introduced by the German biologist Ernst Heinrich Haeckel in 1866. It derived from the Greek *oikos* ("household"), sharing the same root word as *economics*. Thus, th term implies the study of the economy of nature. Modern ecology, in part, began with Charles Darwin.

Q: Define ecosystem and describe its components.

Ecosystem

An ecosystem can be defined as 'a structural and functional unit of biosphere or segmen of nature consisting of community of living beings and the physical environment, both interacting and exchanging materials between them'.

An ecosystem may be natural (like forest, lake, ocean etc) or man-made (such as a aquarium, a crop field etc), temporary (like a rainfed pond) or permanent (like a lake, forest, etc aquatic (such as pond, ocean etc) or terrestrial (like grassland, forest, etc). An ecosystem may b as small as a drop of pond water and as large as an ocean. Ecosystems can be recognised as self regulating and self - sustaining units.

The term ecosystem was coined in 1935 by the Oxford ecologist Arthur Tansley encompass the interactions among biotic and abiotic components of the environment at a give site. The living and non-living components of an ecosystem are known as biotic and abio components, respectively.

Smith (1966) has summarized common characteristics of most of the ecosystems as follows:

1. The ecosystem is a major structural and functional unit of ecology.
2. The structure of an ecosystem is related to its species diversity in the sense that comp ecosystem have high species diversity.
3. The function of ecosystem is related to energy flow and material cycles within a outside the system.

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4. The relative amount of energy needed to maintain an ecosystem depends on its structure. Complex ecosystems needed less energy to maintain themselves.
5. Young ecosystems develop and change from less complex to more complex ecosystems. through the process called succession.
6. Each ecosystem has its own energy budget, which cannot be exceeded.
7. Adaptation to local environmental conditions is the important feature of the biotic components of an ecosystem, failing which they might perish.
8. The function of every ecosystem involves a series of cycles, e.g., water cycle, nitrogen cycle, oxygen cycle, etc. these cycles are driven by energy. A continuation or existence of ecosystem demands exchange of materials/nutrients to and from the different components.

Types of Ecosystem:

We can classify ecosystems as follows:

(a) **Natural Ecosystems:** These ecosystems are capable of operating and maintaining themselves without any major interference by man.

A classification based on their habitat can further be made:

1) Terrestrial ecosystems: forest, grassland and desert.
2) Aquatic ecosystems: fresh water ecosystem, viz. pond, lake, river and marine ecosystems, viz. ocean, sea or estuary.

(b) **Artificial Ecosystem:**

These are maintained by man. These are manipulated by man for different purposes, e.g., croplands, artificial lakes and reservoirs, townships and cities.

Basic Structure of an Ecosystem:

Every ecosystem has a non-living (abiotic) and living (biotic) components.

Abiotic Components:

Basic inorganic compounds of an organism, habitat or an area like carbon dioxide, water, nitrogen, calcium, phosphorus, etc. that are involved in the material cycles are collectively called as abiotic component. The amount of these inorganic substances present at any given time, in an ecosystem is called as the standing state or standing quality of an ecosystem. Whereas, organic components e.g., proteins, amino acids, carbohydrates and lipids that are synthesized by the biotic counterpart of an ecosystem make the biochemical structure of the ecosystem. The physical environment, viz. climatic and weather conditions are also included in the abiotic structure of the ecosystem.

Biotic Components:

From the trophic (nutritional) point of view, an ecosystem has autotrophic (self-nourishing) and a heterotrophic (other nourishing) components:

(a) **Autotrophic component (Producers):**

This component is mainly constituted by the green plants, algae and all photosynthetic organisms. Chemosynthetic bacteria, photosynthetic bacteria, algae, grasses, mosses, shrubs, herbs and trees manufacture food from simple inorganic substances by fixing energy and are therefore called as producers.

(b) **Heterotrophic component (Consumers):**

The members of this component cannot make their own food. They consume the matter built by the producers and are therefore called as consumers. They may be herbivores, carnivores or omnivores. Herbivores are called as primary consumers whereas carnivores and omnivores are called as secondary consumers. Collectively we can call them as macro-consumers.

(c) Decomposers:
Heterotrophic organisms chiefly bacteria and fungi that breakdown the complex compounds of dead protoplasm, absorb some of the products and release simple substances usable by the producers are called as decomposers or reducers. Collectively we call them as micro consumers.

Biotechnology (CSS 2013)

Biotechnology is the use of microbes, or life processes to produce materials and products that are useful to mankind. That is to say, any technique that uses living organisms, or parts of organisms, to make or modify products, improve plants or animals, or to develop microorganisms for specific uses can be defined as biotechnology

The United Nations Convention on Biological Diversity defines biotechnology as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use".

The field of modern biotechnology is thought to have largely begun on June 16, 1980, when the United States Supreme Court ruled that a genetically modified microorganism could be patented in the case of Diamond vs. Chakrabarty. Indian-born Ananda Chakrabarty, working for General Electric, had developed a bacterium, derived from the Pseudomonas genus, capable of breaking down crude oil, which he proposed to use in treating oil spills.

Today, besides healthcare and agriculture, biotechnology has applications in non food (industrial) uses of crops and other products (e.g. biodegradable plastics, vegetable oil, biofuels), and environmental uses. For example, one application of biotechnology is the directed use of organisms for the manufacture of organic products (examples include beer and milk products). Another example is using naturally present bacteria by the mining industry in bioleaching. Biotechnology is also used to recycle, treat waste, cleanup sites contaminated by industrial activities (bioremediation), and also to produce biological weapons.

In recent years our understanding of biotechnology has accelerated and as a result biotechnology has come to indicate the application of a much more sophisticated set of techniques and tools. These tools and techniques, taken from biochemistry, immunology, microbiology, cell biology and chemistry, are used to address a variety of problems.

Biotechnology has vast potential for use in Agriculture, Forestry, Horticulture, Medicine, Food Industry, Chemical Industry, Pollution Control and Environment.

(I) Agriculture

The applications of biotechnology to agriculture are vast. The following activities will help to ensure sustain development in agriculture.

(a) Genetic engineering:
Crop plants like wheal maize, corn, cotton, potato etc. can be developed endowed with extra genes for disease and pest resistance and high yielding through genetic engineering.

(b) Hybrid seeds:
Hybrid seeds can be developed through biotechnology by union of two different genotypes which is superior to its parents under different agromic conditions. It is very successful in vegetable crops like brinjal, tomato, cucurbita etc.

(c) Tissue culture: A major thrust area in biotechnological research in Pakistan is tissue culture A lot of research has gone into plant tissue culture technology in Pakistan over the last

decade. with the result that the country today stands at a new threshold the point where the technology can be taken from inside the laboratory to large-scale commercial farms Various vegetative plants of agricultural, horticultural and plantation crops can be developed through micro propagation, clonal propagation, and somatic embryogenesis

(d) BiofertHizers: Biotechnology plays a major role in developing biofertilisers.A numbers of micro-organisms have ability to fix atmospheric nitrogen and enhance the fertility of soil. Hence these micro-organisms are called biofertilisers" (bio = living and fertilisers). The best examples are

(i) Blue green algae: such as Anabana, Anabamopsis, Nostoc and Tolypothrix etc.
(ii) **Free living bacteria** like Azotobacter, Mycobacterium, Closteriainum, Rhodospirillum, Bacillus, Escherichia etc.
(ii) **Symbiotic bacteria,** like Rhizobium Legumisorium for Legume Plants.

(e) Bio-insecticides and bio-pesticides: Biotechnology has reduced the use of pesticides and insecticides by developing pests and insect's resistance varieties of crop plants and biocontrol agents.

(II) Animal Husbandry

Biotechnological applications in the fields of animal husbandry include production of superior breeds through cell fusions or hybridoma technology, improving health by developing safe and efficient vaccines for infectious diseases, embryo transfer, animal cell culture etc. In the field of fisheries, biotechnology contributes development of feed of fish and prawn larvae, production of fish growth hormones by DNA technology, enhancement of nutritive value of fish and prawns through gene technologies, increasing production of fisheries through hormone technologies etc.

Artificial insemination acts as a powerful device to produce desired type of animal with increased potential. Calves can be produced from frozen and preserved cattle embryos. Now, it is possible to develop an exact copy of mother animal through Chiming Technology. Without any aid from its male counterpart, an Ireland ewe, Dolly is developed through cloning recently from her mother.

(III) Human Health

The developments of human insulin through microbes and human growth hormone for treatment of dwarf sin have already been achieved. Researches are done for developing monoclonal antibodies for cancer and sexually transmitted diseases diagnosis, treatment of cancer and detection of tambour metastasis easy bone marrow transplantation methodology development of interferon's, blood clotting factors and many more^

(IV) Food

In the field of food industry, biotechnology is mainly applied for increasing nutritive value of food, better preservation, enhancement of flavor and protein content and prevention due to spoilage of food. Mass cultivation of mushrooms and food algue spiraling are also encouraged through biotechnology as they have higher protein content.

(V) Industry

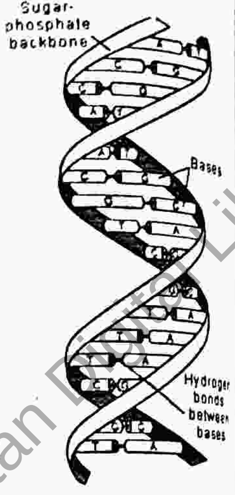
From production of biomass and biogas for energy to biosensors for environmental monitoring, biotechnology plays a crucial role in industry. It is employed in biodegradation of plastics and polymers, management of pesticides in environment, treatment of sewage and industrial effluents, using microbes for oil drilling, microbial application for bioleaching, degradation of solid waters, sewage treatment etc.

Production of biogas and liquid fuel like methane, ethane and from agriculture wastes through fermentation is a significant achievement. Application of biotechnology is increasi by day with its entry to the new and newer fields. Really, we can simply say that biotechn has brought a great revolution to our present day life

Genetic Engineering

Genetic Engineering, alteration of an organism's genetic, or hereditary, materia eliminate undesirable characteristics or to produce desirable new ones. Genetic engineeri used to increase plant and animal food production; to help dispose of industrial wastes, an diagnose disease, improve medical treatment, and produce vaccines and other useful d Included in genetic engineering techniques are the selective breeding of plants and anim hybridization (reproduction between different strains or species), and recombin deoxyribonucleic acid (DNA).

Recombination DNA



In recent decades, genetic engineering has been revolutionized by a technique known as gene splicing, which scientists use to directly alter genetic material to form recombinant DNA. Genes consist of segments of the molecule DNA. In gene splicing, one or more genes of an organism are introduced to a second organism. If the second organism incorporates the new DNA into its own genetic material, recombined DNA results. Specific genes direct an organism's characteristics through the formation of proteins such as enzymes and hormones. Proteins perform vital functions—for example, enzymes initiate many of the chemical reactions that take place within an organism, and hormones regulate various processes, such as growth, metabolism, and reproduction. The introduction of new genes into an organism essentially alters the characteristics of the organism by changing its protein makeup

Process of Recombinant DNA Technology

rDNA stands for recombinant DNA.

DNA is the keeper of the all the information needed to recreate an organism. All DNA is made up of a base consisting of sugar, phosphate and one nitrogen base. There are four nitrogen bases

- Adenine (A)
- Thymine (T)
- Guanine (G)
- Ctosine (C)

The nitrogen bases are found in pairs, with A & T and G & C paired together. The sequence of the nitrogen bases can be arranged in an infinite ways, and their structure is known as the famous "double helix" which is shown in the image below.

The sugar used in DNA is deoxyribose. The four nitrogen bases are the same for all organisms. The sequence and number of bases is what creates diversity. DNA does not actually make the organism, it only makes proteins. The DNA is transcribed into mRNA and mRNA is translated into protein, and the protein then forms the organism. By changing the DNA sequence

the way in which the protein is formed changes. This leads to either a different protein, or an inactive protein.

DNA is, this is where the recombinant comes in. Recombinant DNA is the general name for taking a piece of one DNA, and combining it with another strand of DNA. Thus, the name recombinant' Recombinant DNA is also sometimes referred to as "chimera." By combining two or more different strands of DNA, scientists are able to create a new strand of DNA. The most common recombinant process involves combining the DNA of two different organisms.

How is Recombinant DNA made?

Transformation

The first step in transformation is to select a piece of DNA to be inserted into a vector.

The second step is to cut that piece of DNA with a restriction enzyme and then ligate the DNA insert into the vector with DNA Ligase.

The insert contains a selectable marker which allows for identification of recombinant molecules.

An antibiotic marker is often used so a host cell without a vector dies when exposed to a certain antibiotic, and the host with the vector will live because it is resistant.

The vector is inserted into a host cell, in a process called transformation.

One example of a possible host cell is E. Coli

The host cells must be specially prepared to take up the foreign DNA.

Selectable markers can be for antibiotic resistance, color changes, or any other characteristic which can distinguish transformed hosts from untransformed hosts.

Different vectors have different properties to make them suitable to different applications.

Some properties can include symmetrical cloning sites, size, and high copy number.

Applications of Genetic Engineering

There is no denying the marvels of genetic research. Many things that men only dreamed of have not become a reality with more in the list. As more knowledge is gained and further positive results are obtained, the total number of areas where they can be implemented would only rise. Some of the various areas where their usage has been beneficial are:

Applications in Medicines:

A majority of the findings of genetic research have proved to be of great significance to the medical world. With different kinds of vaccines, antibodies and vitamins developed and easily available in the market, many diseases are now under control and can be treated. These elements can be injected into the bodies of the patient. Chemotherapy and Radiology, which are very prominently used in cases of terminal diseases, are a gift of nothing but genetic research. Treatment of heredity diseases too is possible by manipulating the genes in the human body before birth. What could be better than having a baby devoid of any problems but with all wanted traits?

Applications in Industries:

Synthetically produced items are now available in the markets which are used as raw materials by the industrialists. Commercially viable items can also be produced by using the biological procedures like fermentation (in bakeries). Genetic Research has been able to tell exactly what percentage and what quantities of items should be used for optimum results making everything calculated and risk free.

Applications in Agriculture

Artificially synthesized fruits and vegetables is just one of the many aspects. Fertilizers and bio synthesizers which help in proper growth of crops at the same time killing the harmful bacteria have helped the agriculture sector. If added nutrients are added to the soil, the produce is of better quality and of higher quantity, both of which are very beneficial. The soil does not lose its potential to grow more crops which allow for the agriculture process to be carried out all through the year. Added experiments are being carried out to make plants which are self dependent and would only be need to sown once. Emphasis is also paid on discovering plants which do not require high amounts of water.

Applications for Humans:

Scientists are pondering over the possibility of making children with only the desirable traits are possible after the successes in cloning. This could do away with a majority of diseases and no vaccination would be required. Babies who have deficiency could be treated with additions being done to their genetic structure. Those who cannot reproduce due to medical complications have also seen positive results with surrogate parent's concept becoming available.

Applications for Environment:

Organisms have been known to help in the bio degradation of waste materials. However, there are some materials like plastics which cannot be degraded by them. To help such causes, genetic research has produced modified microorganisms which not only have the capability of doing this but are also more efficient due to the speedy process. They are used in situations which may cause severe damage to the planet earth like oil spills.

Controversies

Public reaction to the use of recombinant DNA in genetic engineering has been mixed. The production of medicines through the use of genetically altered organisms has generally been welcomed. However, critics of recombinant DNA fear that the *pathogenic*, or disease-producing organisms used in some recombinant DNA experiments might develop extremely infectious forms that could cause worldwide epidemics.

Animal rights groups have argued that the production of transgenic animals is harmful to other animals. Genetically engineered fish raise problems if they interbreed with other fish that have not been genetically altered. Some experts fear that this process may change the characteristics of wild fish in unpredictable and possibly undesirable ways. A related concern is that engineered fish may compete with wild fish for food and replace wild fish in some areas.

Difference *between* Biotechnology *and* Genetic Technology

People have been using biotechnology for millennia. This technology is based on the use of microorganisms, which e.g. ferment the sugar in barley to alcohol during beer production. Other examples of everyday products that undergo biotechnological processing are cheese, yogurt, vinegar, wine, yeast, and sourdough. Without knowledge of the exact backgrounds, our ancestors used these methods to discover and improve a range of applications that made their life easier. Genetic engineering is a modern subspecialty of biotechnology. It is concerned with the targeted modification of the genetic material of bacteria or plants, for example to stimulate them to biosynthesize desired products. Today genetic engineering is primarily used in the field of medicine, but is also applied in industry and agriculture.

Genetic Engineering Examples

- **Cloning** - One of the most controversial uses of genetic engineering has been cloning, or producing a genetically identical copy of an organism. While the ethics of cloning are hotly debated, the first ever sheep (named Dolly) was cloned in 1996 by scientists.
- **Glow-in-the-dark cats** - It sounds strange, but in 2007, scientists in South Korea altered the DNA of a kitty so that its fur would glow in the dark, and then cloned other cats from it, making the world's first glowing cats.

- **Pesticide-resistant rapeseed plants** - Rapeseed is a flowering plant used to make certain types of vegetable oil. Genetic engineering has allowed these plants to be resistant to certain types of pesticides, so that when the fields are treated to remove pests, the plants will remain unscathed.
- **Plants that fight pollution** - Poplar trees developed by scientists at the University of Washington can absorb polluted water through their roots and clean it before the water is released back into the air. The plants were many times more efficient at cleaning certain pollutants than regular poplars.
- **Golden rice** - Genetic modification is often used to make "healthier" foods, such as golden rice, which contains beta-carotene - the very same vitamin that makes carrots orange. The result is that people without access to many vitamins will get a healthy dose of vitamin A when the rice is consumed.
- **Faster-growing trees** - Demand for wood can be met by trees that grow faster than average. Genetic engineering has produced trees that can ward off biological attacks, grow more quickly and strongly, and create better wood than trees that are not genetically modified.
- **Bigger, longer-lasting tomatoes** - When tomatoes are genetically engineered, they can be made bigger and more robust. These are engineered to produce tomatoes that can remain fresh for longer, can be shipped farther from where they are grown, and can be harvested all at the same time rather than harvesting only parts of a field at each harvest.
- **The banana vaccine** - Bananas were developed through genetic modification that offer vaccine against diseases such as cholera and hepatitis. Just like with a needle vaccine, people who eat them develop disease-combating antibodies that make them immune to a disease.

Human Physiology

In the 8th century AD. *Abu Bakar Al Razi* first described some key physiological characteristics of human body. Subsequently, it was another Muslim scientist by the name of *Al Kindi* who wrote a paper on human physiology. Later in the 17th century, the anatomist *William Harvey* wrote about the human blood circulation, thus starting the field later came to be known as experimental physiology. Another prominent figure in the history of the field of physiology is *Herman Boerhaave* who is often called the *father of physiology*.

Human physiology is the scientific study of various functions of the human body in its normal state. These functions could be mechanical or biochemical in nature. The study of animal physiology and related experiments has provided much of the basis for studying human physiology. Along with anatomy, human physiology is one of the basic sciences in the medical field with its application throughout the medical care.

To maintain normal human health, the physiological variables such as blood glucose, body temperature, blood chemistry, etc. must be maintained within a narrow range. One of the principal concepts in human physiology is called homeostasis, which means the maintenance of a stable internal body environment despite changes in the external environment. In fact, the main function of many human organ systems is to maintain this homeostasis. For example, the renal or kidney system works to maintain normal water levels and normal blood chemistry in the body via urination and elimination of various waste products. Similarly, the job of the circulatory system is to maintain a constant and adequate supply of oxygen and nutrients to various organs as well as removal of waste products

Human Physiology: Major Systems

Following are the major system of the human body

- Circulatory System
- Respiratory System
- Digestive System
- Renal System
- Immune System
- Nervous System
- Musculoskeletal System
- Reproductive System

Circulatory System

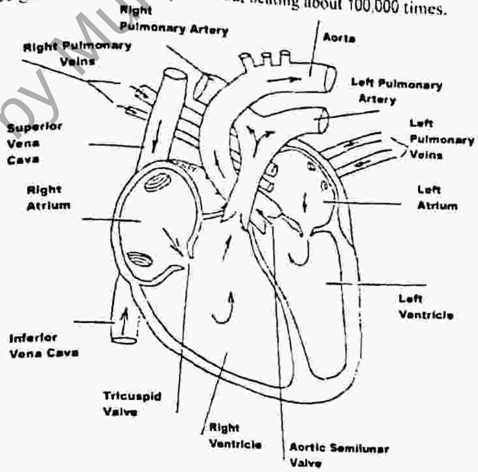
The circulatory system is made up of the vessels and the muscles that help and control the flow of the blood around the body. This process is called circulation. The main parts of the system are the heart, arteries, capillaries and veins.

As blood begins to circulate, it leaves the heart from the left ventricle and goes into the aorta. The aorta is the largest artery in the body. The blood leaving the aorta is full of oxygen This is important for the cells in the brain and the body to do their work. The oxygen rich blood travels throughout the body in its system of arteries into the smallest arterioles.

On its way back to the heart, the blood travels through a system of veins. As it reaches the lungs, the carbon dioxide (a waste product) is removed from the blood and replace with fresh oxygen that we have inhaled through the lungs.

Human Heart

The heart is a fist-sized, muscular organ that pumps blood through the body. Oxygen-poor blood enters the right atrium of the heart *(via veins called the inferior vena cava and the superior vena cava)*. The blood is then pumped into the right ventricle and then through the pulmonary artery to the lungs, where the blood is enriched with oxygen *(and loses carbon dioxide)*. The oxygen-rich (*oxygenated*) blood is then carried back to the left atrium of the heart via the pulmonary vein. The blood is then pumped to the left ventricle, then the blood is pumped through the aorta and to the rest of the body. This cycle is then repeated. Every day, the heart pumps about 2,000 gallons (7,600 liters) of blood, beating about 100,000 times.



How the Heart Works

The human heart has four chambers. The two upper chambers are called the atria. The two lower chambers are called the ventricles. The atria receive blood returning to the heart, and then push it downward to the ventricles. The vent ricles, which are larger and stronger, give departing blood a push outward towards its destination

The heart is in fact two pumps. The right side receives de-oxygenated blood from the body and pumps blood to the lungs to pick up oxygen. The much stronger left ventricle takes oxygenated blood coming back from the lungs and circulates it to the rest of the body.

Blood flows through the body in an endless, figure eight loop.

- The right ventricle pumps blood to the lungs so it can get oxygen.
- Blood returning from the lungs arrives in the left atrium, which pushes if downward to the left ventricle
- The left ventricle pumps blood out to rest of the body, taking the oxygen out where it will be used by muscles and other tissues to do their work

- Blood returning from various parts of the body arrives in the right atrium. From there it goes to the right ventricle for another trip through the lungs so it can get more oxygen, and the cycle continues.

Blood circulates in two loops as it flows through the heart.

Your heart has four chambers:

1. **The right atrium**: Receives venous blood from the body
2. **The right ventricle**: Pumps venous blood to the lungs for oxygen
3. **The left atrium**: Receives oxygenated blood from the lungs
4. **The left ventricle**: Pumps blood out to the body through the arteries

Normally, the right side pumps blood only to the lungs. The left side pumps blood to the rest of the body. For that reason, the left side needs to pump harder; generally, there's three to four times as much pressure on the left side

Valves control the direction of blood from the atrium to the ventricle, and from the ventricles into the main arteries.

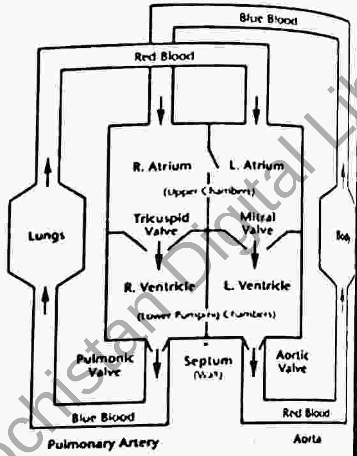
Heart defects like Atrial Septal Defect (ASD). Ventricular Septal Defect (VSD), or Patent Ductus Arteriosus (PDA) allow blood to escape from the left to the right side through an abnormal hole or passageway. Doctors call this a "left to right shunt". The exception is Patent Foramen Ovale (PFO); which is a right to left shunt.

The heart is made of strong muscle, called myocardium, and sits in a sac of fibrous tissue -the pericardium. The heart's inner surface, which is in contact with the blood being pumped, is called the endocardium

Coronary Arteries

The coronary arteries supply blood to the heart. They arise just distal to the aortic valve in the Sinuses of Valsalva and traverse the heart's outer surface

The right coronary artery supplying the right side of the heart contains only one major branch, while left coronary artery contains two branches, the left anterior descending branch (LAD) and the circumflex branch. Smaller branches from the major branches penetrate the myocardium. About 4-5% of the total circulating blood flows through the coronary arteries



Normal Blood Circulation

Blood Circulation

Blood returning from a trip around the body has given up most of its oxygen and picks up carbon dioxide in the body's tissues. This oxygen-poor blood feeds into two large veins, the superior vena cava and inferior vena cava, which empty into the right atrium of the heart.

The right atrium conducts blood to the right ventricle, and the right ventricle pumps

blood into the pulmonary artery. The pulmonary artery carries the blood to the lungs, where it picks up a fresh supply of oxygen and eliminates carbon dioxide. The blood, now oxygen-rich, returns to the heart through the pulmonary veins, which empty into the left atrium. Blood passes from the left atrium into the left ventricle, from where it is pumped out of the heart into the aorta, the body's largest artery. Smaller arteries that branch off the aorta distribute blood to various parts of the body.

The arteries, veins, and capillaries are divided into two systems of circulation: systemic and pulmonary.

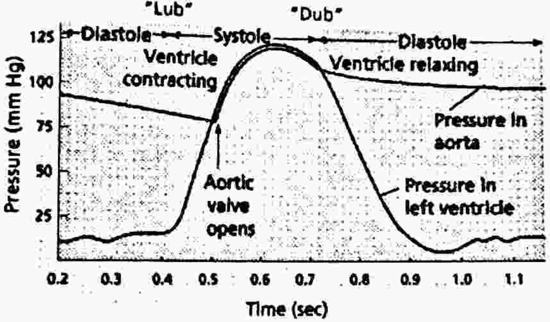
- **The systemic circulation** carries oxygenated blood from the heart to all the tissues in the body except the lungs and returns deoxygenated blood carrying waste products, such as carbon dioxide, back to the heart.
- **The pulmonary circulation** carries this spent blood from the heart to the lungs. In the lungs, the blood releases its carbon dioxide and absorbs oxygen. The oxygenated blood then returns to the heart before transferring to the systemic circulation.

The circulatory system plays an important role in regulating body temperature. During exercise, working muscles generate heat. The blood supplying the muscles with oxygen and nutrients absorbs much of this heat and carries it away to other parts of the body. If the body gets too warm, blood vessels near the skin enlarge to disperse excess heat outward through the skin. In cold environments, these blood vessels constrict to retain heat.

Cardiac Cycle

A healthy heart makes a "*lub-dub*" sound with each beat. Here is what happens to make that sound: One complete heartbeat makes up a cardiac cycle, which consists of two phases. In the first phase, the ventricles contract (*this is called the systole*), sending blood into the pulmonary and systemic circulation. To prevent the flow of blood backwards into the atria during systole, the atrioventricular valves close, creating the first ("*lub*") sound.

When the ventricles finish contracting, the aortic and pulmonic valves close to prevent blood from flowing back into the ventricles. This is what creates the second sound (*the "dub"*). Then the ventricles relax (*this is called diastole*) and fill with blood from the atria, which makes up the second phase of the cardiac cycle.



A unique electrical system in the heart causes it to beat in its regular rhythm. The sinoatrial or SA node, a small area of tissue in the wall of the right atrium, sends out an electrical signal to start the contracting of the heart muscle. These electrical impulses cause the atria to contract first; they then travel down to the atrioventricular or AV node, which acts as a kind of relay station. From here the electrical signal travels through the right and left ventricles, causing them to contract and force blood out into the major arteries.

A lubb happens when the upper chambers of the heart contract to squeeze the blood downward into the ventricles. A dubb happens when the lower chambers contract.

Blood Pressure

Blood pressure represents the force (pressure) exerted by blood against the arterial walls during a cardiac cycle (heart beat) which consists of heart muscle contraction (systole) and heart muscle relaxation (diastole).

Systolic blood pressure, the higher of the two pressure measurements, occurs as the heart muscles contract pumping blood into the aorta. Heart muscles then relax allowing the heart to refill with blood and the lowest pressure reached represents the diastolic blood pressure.

Normal systolic blood pressure in an adult varies between 110 and 140 mm Hg, and diastolic pressure varies between 60 and 90 mm Hg. (*Note: "mm Hg" means millimeters of mercury*)

Classification of blood pressure levels

Systolic(mm Hg)	Diastolic(mm Hg)	Classification
<130	<85	Normal
130-139	85-89	High Normal
140-159	90-99	Hypertension (stage 1)
160-179	100-109	Moderate Hypertension (stage 2)
>180	>110	Severe Hypertension (stage 3)

Ref: *NICE clinical guideline*

What is Hear Beat/ Pulse?

A heartbeat has two parts. They are sometimes called lubb and dubb because those are the sounds that a doctor hears. A lubb happens when the upper chambers of the heart contract to squeeze the blood downward into the ventricles. A dubb happens when the lower chambers contract.

Every time the lower chambers of the heart contract, the blood in the left ventricle rushes upward into the aorta. It quickly speeds away from the heart causing the aorta to expand as it passes. As the blood races along, some of it pushes into the first artery that branches off from the aorta. Some of the blood enters the next artery. The blood from each contraction of the heart produces a bulge in the artery. We call that bulge a pulse. One pulse equals one heartbeat.

What is Heart Rate?

Heart rate is determined by the number of heartbeats per unit of time, typically expressed as beats per minute (BPM), it can vary with as the body's need for oxygen changes, such as during exercise or sleep. The normal human heart rate ranges from 60–100 bpm. Bradycardia refers to a slow heart rate, defined as below 60 bpm. Tachycardia refers to a fast heart rate, defined as above 100 bpm. When the heart rate is not regular in a regular pattern, this is referred to as an arrhythmia. These abnormalities of heart rate sometimes, but not always, indicate disease. Standard heart rate is 72 beats per minute. If you count 12 beats in the span of **10** seconds multiply 12 x 6 = 72. This means your Heart Rate or pulse, is **72** (or 72 beats per minute).

Heart Facts

- In a healthy, resting adult, the heart beats 60 to 100 times per minute. This amounts to 104,000 beats in 24 hours, or about 2.5 billion beats in an average lifetime of 70 years.

- A normal heart recirculates the 5 to 6 litres of blood in the body every 1-½ minutes. This amounts to over 7,000 litres pumped each day.
- During strenuous activity, a healthy heart must pump four to seven times its normal output

Human Blood

Blood, vital fluid found in humans and other animals that provides important nourishment to all body organs and tissues and carries away waste materials. Sometimes referred to as "the river of life," blood is pumped from the heart through a network of blood vessels collectively known as the circulatory system.

An adult has about 5 to 6 liters (1 to 2 gal) of blood, which is roughly 7 to 8 percent of total body weight. Infants and children have comparably lower volumes of blood, roughly proportionate to their smaller size.

About 55 percent of the blood is composed of a liquid known as plasma. The rest of the blood is made of three major types of cells: red blood cells (*also known as erythrocytes*), white blood cells (leukocytes), and platelets (*thrombocytes*).

- *Human blood* consists of about 22 percent solids and 78 percent water.
- *Human blood temperature* is 38 degrees C or 100.4 degrees F. It is always slightly higher than the normal human body temperature of 37 degrees C or 98.6 degrees F.
- *Blood* has a pH of 7.35-7.45, making it slightly basic (less than 7 is considered acidic).
- *Blood* in the arteries is a brighter red than blood in the veins because of the higher levels of oxygen found in the arteries.
- An artificial substitute for human blood has not been found

Function of Blood

Blood has three main functions: transport, protection and regulation.

Transport

Blood transports the following substances

- Gases, namely oxygen (O_2) and carbon dioxide (CO_2), between the lungs and rest of the body
- Nutrients from the digestive tract and storage sites to the rest of the body
- Waste products to be detoxified or removed by the liver and kidneys
- Hormones from the glands in which they are produced to their target cells
- Heat to the skin so as to help regulate body temperature

Protection

Blood has several roles in inflammation

- Leukocytes, or white blood cells, destroy invading microorganisms and cancer cells
- Antibodies and other proteins destroy pathogenic substances
- Platelet factors initiate blood clotting and help minimise blood loss

Regulation

Blood helps regulate:

- pH by interacting with acids and bases
- Water balance by transferring water to and from tissues

Blood Cells

Blood is classified as a connective tissue and consists of two main components:

1. Plasma, which is a clear extracellular fluid
2. Formed elements, which are made up of the blood cells and platelets

The formed elements are so named because they are enclosed in a plasma membrane th have a definite structure and shape. All formed elements are cells except for the platelets, whic tiny fragments of bone marrow cells.

Formed elements are:

- **Erythrocytes**, also known as *red blood cells* (**RBCs**)
- **Leukocytes**, also known as *white blood cells* (**WBCs**)
- **Platelets**

Red blood cells (RBCs).

Red blood cells (RBCs), also known as erythrocytes, have two main functions:

- To pick up oxygen from the lungs and deliver it to tissues elsewhere
- To pick up carbon dioxide from other tissues and unload it in the lungs

Red blood cells make up almost 45 percent of the blood volume. Their primary function is to carry oxygen from the lungs to every cell in the body. Red blood cells are composed predominantly of a protein and iron compound, called hemoglobin that captures oxygen molecules as the blood moves through the lungs, giving blood its red color. As blood passes through body tissues, hemoglobin then releases the oxygen to cells throughout the body. Red blood cells are so packed with hemoglobin that they lack many components, including a nucleus, found in other cells.

White blood cells (WBCs)

They are also called leucocytes White blood cells only make up about 1 percent of blood, but their small number belies their immense importance. They play a vital role in the body's immune system—the primary defense mechanism against invading bacteria, viruses, fungi, and parasites.

White blood cells also produce antibodies, which are released into the circulating blood to target and attach to foreign organisms. After attachment, the antibody may neutralize the organism, or it may elicit help from other immune system cells to destroy the foreign substance. During leukamia, a cancer of blood, the number of WBCs increases abnormally at the cost of the number of RBCs usually resulting in death. They are of five distinct types whose life span varies from 12 hours to 300 days.

The leucocytes are basically of two types:

- Granular leucocytes
- Agranular leucocytes

Granulocytes *Granular leucocytes*

The leucocytes have granular cytoplasm. They are of three types based on the stains they take:

- Neutrophils
- Eosinophils
- Basophils

Neutrophils

Neutrophils contain neutral-staining granules. The nucleus is 2 to 7 lobed. They number 3000 to 6000 per cubic mm. Their life span is 12 hours to 3 days. Their function is phagocytosis of bacteria.

Eosinophil's

Eosinophils contain granules that take acidic stains like eosin. The nucleus is 2 to 3 lobed. They number 100 to 400 per cubic mm. Their life span is 3 to 5 days. Their function is thought to be anti-allergic properties.

Basophils

Basophils contain granules that take basic stain. The nucleus is variously lobed. They number 25 to 200 per cubic mm. Their life span is 9 to 18 months. They develop into mast cells of the connective tissue.

Agranulocytes *Agranular leucocytes*

The cytoplasm is devoid of granules. They are of two types based on their origin:

- Lymphocytes
- Monocytes

Lymphocytes

They are produced in the lymph system. Their nucleus is large and occupies most of the cell. The cytoplasm is basophilic. They are more in number in children than in adults. They have a life span of 100 - 200 days. Their functions are phagocytosis and antibody-production.

Monocytes

They are produced in the bone marrow. They have a large kidney-shaped nucleus. The cytoplasm is more than in lymphocytes. They number 100 to 700 per cubic mm. They function as tissue macrophages feeding on damaged tissues.

The WBCs are involved in the production of antibodies that either neutralise, kill or poison the germs. The WBCs can be induced to produce antibodies with the help of vaccinations thus preparing the body for an attack.

Platelets

The smallest cells in the blood are the platelets, which are designed for a single purpose—to begin the process of coagulation, or forming a clot, whenever a blood vessel is broken. As soon as an artery or vein is injured, the platelets in the area of the injury begin to clump together and stick to the edges of the cut. They also release messengers into the blood that perform a variety of functions: constricting the blood vessels to reduce bleeding, attracting more platelets to the area to enlarge the platelet plug, and initiating the work of plasma-based clotting factors, such as fibrinogen. Through a complex mechanism involving many steps and many clotting factors, the plasma protein fibrinogen is transformed into long, sticky threads of fibrin. Together, the platelets and the fibrin create an intertwined meshwork that forms a stable clot. This self-sealing aspect of the blood is crucial to survival.

Difference *between*

WBC *(or White Blood Corpuscles)* **Leukocytes** *and* **RBC** *(Red Blood Corpuscles)* **Erythrocytes**

	RBCs	**WBCs**
Physical features:	RBCs are bi-concave disc shaped, and have no nucleus, size is roughly approximately 6-8 μm	WBCs are irregular in shape, but have a nucleus and an outer buffer coat.
Life span:	120 days.	Few days but can live several days to yrs in healthy body.
Types:	There is only one type of RBCs found in the blood.	There are various types of WBCs with distinct functions in the blood: neutrophils, ***T*** lymphocytes, ***B*** lymphocytes (*plasma cell*) monocytes (*macrophage*), eosinophils, basophils.
Circulatory system:	Cardiovascular system	Cardiovascular and lymphatic

		systems.
Total count RBC 700:1 WBC:	males 4.6 million - 6.2 million per cubic mm females 4.2 million-5.4 million per cubic mm	4000 - 11000 per cubic mm
Functions:	Supplies oxygen to different parts of the body and carries carbon dioxide and other waste products.	Producing antibodies to develop immunity against infections. Some are phagocytic
Presence in blood:	Makes up 36-50% of our blood depending on sex, height & weight	Close to 1% of the blood.
Components	Hemoglobin	Antibodies with MHC antigen cell markers
Production:	Produced in red bone marrow.	Produced in lymph nodes, spleen, etc.
Movement:	They move in blood vessels eventually squeezing through capillaries giving O2 and nutrients to body cells.	They leave the blood vessels and move to the injury site. Capable of diapedesis-squeeze between cells of blood vessel walls to exit circulation.
Nuclei:	Biconcave disc	Have different kinds of shapes and don't change shape when multiplied

Production of Blood Cells

Blood is produced in the bone marrow, a tissue in the central cavity inside almost all of the bones in the body. In infants, the marrow in most of the bones is actively involved in blood cell formation. By later adult life, active blood cell formation gradually ceases in the bones of the arms and legs and concentrates in the skull, spine, ribs, and pelvis.

Red blood cells, white blood cells, and platelets grow from a single precursor cell, known as a hematopoietic stem cell. Remarkably, experiments have suggested that as few as 10 stem cells can, in four weeks, multiply into 30 trillion red blood cells, 30 billion white blood cells, and 1.2 trillion platelets—enough to replace every blood cell in the body.

Red blood cells have the longest average life span of any of the cellular elements of blood. A red blood cell lives 100 to 120 days after being released from the marrow into the blood.

The majority of white blood cells have a relatively short life span. They may survive only 18 to 36 hours after being released from the marrow.

Blood Types

Blood typing is important for many medical reasons. If a person loses a lot of blood, that person may need a blood transfusion to replace some of the lost red blood cells. Since everyone makes antibodies against substances that are foreign (not of their own body), transfused blood must be matched so as not to contain these substances. Here the Rh factor does not come into play.

For example, a person who is blood type A positive will not make antibodies against the A or Rh markers. But they will make antibodies against the B marker, which is not on that person's own red blood cells. If blood containing the B marker (from types B positive, B negative, AB positive, or AB negative) is transfused into this person, then the transfused red blood cells will be rapidly destroyed by the patient's antibodies. In this case, the transfusion will do the patient no good and may even result in serious harm.

There are several types of red blood cells and each person has red blood cells of just one type. Blood type is determined by the occurrence or absence of substances, known *as recognition markers or antigens*, on the surface of the red blood cell.

Type **A** blood has just marker **A** on its red blood cells while type **B** has only marker **B**. If neither **A** nor **B** markers are present, the blood is type **O**. If both the **A** and **B** markers are present, the blood is type **AB**.

Another marker, the **Rh** antigen (*also known as the Rh factor*), is present or absent regardless of the presence of **A** and **B** markers. If the **Rh** marker is present, the blood is said to be **Rh** positive, and if it is absent, the blood is **Rh** negative.

The most common blood type is A positive. This means that the blood has an A marker and also an Rh marker. More than 20 additional red blood cell types have been discovered.

For a successful blood transfusion into an **A positive** blood type individual, blood that is type **O negative, O positive, A negative, or A positive** is needed because these blood types will not be attacked by the patient's anti-B antibodies. The Rh factor is not material. The blood type O is usually called the **universal donor** group. Blood of the type can normally be given to all blood types. Likewise the type AB is called **the universal recipient** group because it can accept A, B, AB and O types of blood. Remember that **the Rh factor is not material.** The discovery of the ABO blood group, over 100 years ago, caused great excitement. Until then, all blood had been assumed to be the same, and the often tragic consequences of blood transfusions were not understood.

Blood Component ABO Compatibility Chart

Blood Group	**Antigen** *on Red Cells*	**Antibody** *in Serum*	*From* **Whom** *it can* **Receive**	*To* **Whom** *it can* **Donate**
O	No A or B	Anti-A /Anti-B	O	O/A/B/AB
A	A	Anti-B	A/O	A/AB
B	B	Anti-A	B/O	B/AB
AB	A and B	None	AB/A/B/O	AB

Blood Disorders

Blood disorders can affect any of the three main components of blood:

- Red blood cells, which carry oxygen to the body's tissues
- White blood cells, which fight infections
- Platelets, which help blood to clot

Blood disorders can also affect the liquid portion of blood, called plasma.

Blood Disorders Affecting Red Blood Cells

Blood disorders that affect red blood cells include:

Anemia: People with anemia have a low number of red blood cells. Mild anemia often causes no symptoms. More severe anemia can cause fatigue, pale skin, and shortness of breath with exertion.

- **Iron-deficiency anemia:** Iron is necessary for the body to make red blood cells. Low iron intake and loss of blood due to menstruation are the most common causes of iron-deficiency anemia. Treatment includes iron pills, or rarely, blood transfusion.
- **Anemia of chronic disease:** People with chronic kidney disease or other chronic diseases tend to develop anemia. Anemia of chronic disease does not usually require treatment. Injections of a synthetic hormone (Epogen, Procrit) to stimulate the production of blood cells or blood transfusions may be necessary in some people with this form of anemia.

- **Pernicious anemia (B12 deficiency):** An autoimmune condition that prevents the bod from absorbing enough B12 in the diet. Besides anemia, nerve damage (neuropathy) ca eventually result. High doses of B12 prevent long-term problems.
- **Aplastic anemia:** In people with aplastic anemia, the bone marrow does not produc enough blood cells, including red blood cells. A viral infection, drug side effect, or a autoimmune condition can cause aplastic anemia. Blood transfusions, and even a bon marrow transplant, may be required to treat aplastic anemia.
- **Thalassemia:** This is a genetic form of anemia that mostly affects people o Mediterranean heritage. Most people have no symptoms and require no treatment. Other may need regular blood transfusions to relieve anemia symptoms.
- **Sickle cell anemia:** A genetic condition that affects mostly African-Americans Periodically, red blood cells change shape, and block blood flow. Severe pain and organ damage can occur.
- **Malaria:** A mosquito's bite transmits a parasite into a person's blood, where it infects red blood cells. Periodically, the red blood cells rupture, causing fever, chills, and organ damage. This blood infection is most common in Africa; those traveling to Africa are at risk and should take preventive measures. Malaria was eradicated from the U.S. in the 1940s.

Blood Disorders Affecting White Blood Cells

Blood disorders that affect white blood cells include:

- **Lymphoma**: A form of blood cancer that develops in the lymph system. In lymphoma, a white blood cell becomes malignant, multiplying and spreading abnormally. Hodgkin's lymphoma and non-Hodgkin's lymphoma are the two major groups of lymphoma. Treatment with chemotherapy and/or radiation can extend life with lymphoma, and sometimes cure it.
- **Leukemia**: A form of blood cancer in which a white blood cell becomes malignant and multiplies inside bone marrow. Leukemia may be acute (rapid and severe) or chronic (slowly progressing). Chemotherapy and/or stem cell transplantation (bone marrow transplant) can treat leukemia, and sometimes result in a cure.

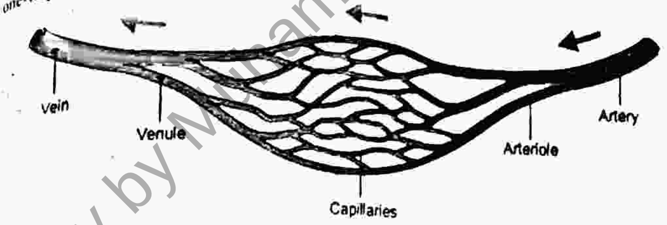
Blood Disorders Affecting Plateles

Blood disorders that affect the platelets include:

- **Thrombocytopenia**: A low number of platelets in the blood. Numerous conditions cause thrombocytopenia; most do not result in abnormal bleeding.
- **Idiopathic thrombocytopenic purpura:** A condition causing a persistently low number of platelets in the blood, due to an unknown cause. Usually there are no symptoms, yet abnormal bruising, small red spots on the skin (petechiae), or abnormal bleeding can result.

Vascular System - *the* Blood Vessels

Arteries, veins, and capillaries comprise the vascular system. Arteries and veins run parallel throughout the body with a web-like network of capillaries connecting them. Arteries use vessel size, controlled by the sympathetic nervous system, to move blood by pressure; veins use one-way valves controlled by muscle contractions.



Arteries

Arteries are strong, elastic vessels adapted for carrying blood **away from the heart** at relatively high pumping pressure. Arteries divide into progressively thinner tubes and eventually become fine branches called *arterioles*. Blood in arteries is oxygen-rich, with the exception of the pulmonary artery, which carries blood to the lungs to be oxygenated.

Capillaries

The arterioles branch into the microscopic capillaries, or *capillary beds*, which lie bathed in *interstitial fluid*, or lymph, produced by the lymphatic system. Capillaries are the points of exchange between the blood and surrounding tissues. Materials cross in and out of the capillaries by passing through or between the cells that line the capillary. The extensive network of capillaries is estimated at between 50,000 and 60,000 miles long

Veins

Blood leaving the capillary beds flows into a series of progressively larger vessels, called *venules*, which in turn unite to form veins. Veins are responsible for returning blood **to the heart** after the blood and the body cells exchange gases, nutrients, and wastes.

Differences *between* Arteries, Capillaries *and* Veins

Arteries	Veins	Capillaries
Carry blood away from the heart	Carry blood towards the heart.	Distributes blood to the cell and tissues
Blood is under great pressure in arteries, hence it flows fast, in spurts, reflecting the rhythmic pumping action of the heart	Blood is not under great pressure in veins, hence it flows more slowly and smoothly.	No pressure or failing pressures
Have thick and elastic muscular walls	Have relatively thin, slightly muscular walls	No muscle or elastic fibers
Have no valves	Have semi-lunar valves along their lengths to prevent backflow of blood	

Carry red oxygenated blood *(exception pulmonary arteries which carry deoxygenated blood from the heart to the lungs)*	Carry bluish-red deoxygenated blood *(exception pulmonary veins which carry oxygenated blood from the lungs to the heart)*	Capillaries carry both red oxygenated blood and deoxygenated blood

Heart Disease

Heart disease, also called cardiovascular disease The heart is the center of the cardiovascular system. Through the body's blood vessels, the heart pumps blood to all of the body's cells. The blood carries oxygen, which the cells need. Cardiovascular disease is a group of problems that occur when the heart and blood vessels aren't working the way they should.

Here are some of the problems that go along with cardiovascular disease:

- **Arteriosclerosis** also called hardening of the arteries, arteriosclerosis means the arteries become thickened and are no longer as flexible.
- **Atherosclerosis** a buildup of cholesterol and fat that makes the arteries narrower so less blood can flow through. Those buildups are called plaque.
- **Angina** people with angina feel a pain in the chest that means the heart isn't getting enough blood.
- **Stroke:** when part of the brain doesn't get enough blood due to a clot or a burst blood vessel.

Lymph

Lymph is a clear-to-white fluid made of:

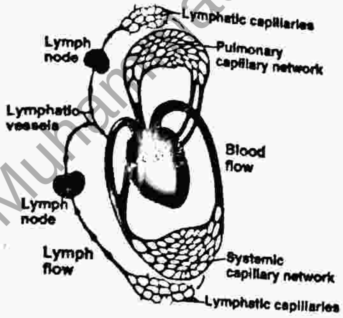
- White blood cells, especially lymphocytes, the cells that attack bacteria in the blood
- Fluid from the intestines called chyle, which contains proteins and fats

Lymph, common name for the fluid carried in the lymphatic system. Lymph is dilute blood plasma containing large numbers of white blood cells, especially lymphocytes, and occasionally a few red blood cells. Because of the number of living cells it contains, lymph is classified as a fluid tissue.

Lymph diffuses into and is absorbed by the lymphatic capillaries from the spaces between the various cells constituting the tissues. In these spaces lymph is known as tissue fluid plasma that has permeated the blood capillary walls and surrounded the cells to bring them nutriment and to remove their waste substances. The lymph contained in the lacteals of the small intestine is known as chyle.

The synovial fluid that lubricates joints is almost identical with lymph, as is the serous fluid found in the body and pleural cavities. The fluid contained within the semicircular canals of the ear, although known as endolymph, is not true lymph.

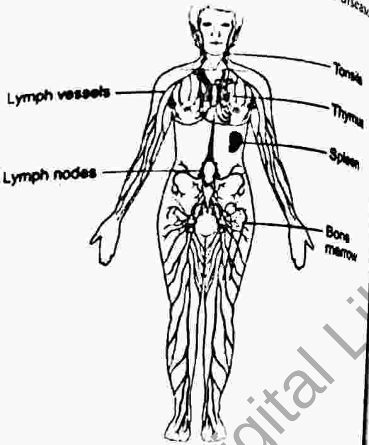
Difference *between* Lymph *and* Blood



Lymph	Blood
Lymphs are colourless due to absence of RBCs	Blood is red in colour due to presence of RBCs
The lymph plasma contains WBCs.	Blood plasma contains RBCs, WBCs and platelets.
It contains diffusible proteins.	It contains diffusible and non-diffusible proteins like albumin, globulin and fibrinogen.
It clotes slowly due to presence of less fibrinogen	It can clot due to presence of more amount of fibrinogen.
It carries less O_2 and less digested products.	It carries more O_2 and more digested food.
Lymph cannot be seen with the naked eyes.	We can see blood if there is damage to the vessels
Lymph is purified in the nodes itself	The kidneys purify the blood

Lymphatic System

Lymphatic System, common name for the circulatory vessels or ducts in which the flu bathing the tissue cells of vertebrates is collected and carried to join the bloodstream proper Th lymphatic system is of primary importance in transporting digested fat from the intestine to th bloodstream; in removing and destroying toxic substances; and in resisting the spread of diseas throughout the body.



The portions of the lymphatic system that collect the tissue fluids are known as lymphatic capillaries and are similar in structure to ordinary capillaries. The lymphatic capillaries that pick up digested fat in the villi of the intestine are known as lacteals. The lymphatic capillaries are more permeable than ordinary capillaries and allow passage of larger particles than would ordinarily pass through capillary walls; large-molecule proteins, produced as a result of tissue breakdown, pass into the lymphatics for transport away from the tissues.

Lymph Nodes

Along the course of the lymphatic vessels are situated the lymph nodes, more commonly called the lymph glands. These nodes are bean-shaped organs containing large numbers of leukocytes, embedded in a network of connective tissue. All the lymph being returned along the lymphatics to the bloodstream must pass through several of thes nodes, which filter out infectious and toxic material and destroy it. The nodes serve as a center fo the production of phagocytes, which engulf bacteria and poisonous substances. During the cours of any infection, the nodes become enlarged because of the large number of phagocytes being produced; these nodes are often painful and inflamed. The swollen glands most often observed are located on the neck, in the armpit, and in the groin. Certain malignant tumors tend to "travel along the lymphatics; surgical removal of all nodes that are suspected of being involved in the spread of such malignancies is an accepted therapeutic procedure.

The Body's Communication System

The Endocrine *and* Nervous System

Both nervous and endocrine systems are the basic systems that regulate the biological processes inside an organism, but through different means of passing signals. Homeostasis is the ability to maintain a constant internal environment in response to environmental changes. It is a unifying principle of biology. The nervous and endocrine systems control homeostasis in the body through feedback mechanisms involving various organs and organ systems. The basic similarities between the nervous and the endocrine systems are that they provide the body with methods to communicate with its internal and external environments in order to coordinate responses. They both employ chemicals to transmit messages and respond to stimulus caused by changes in their environments.

Nervous System vs Endocrine System

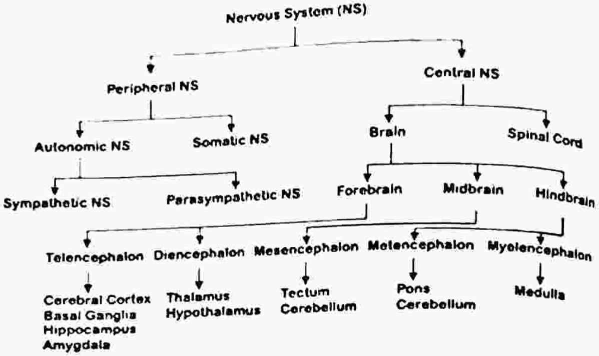
Nervous System	Endocrine System
Formed of a collection of neuron cells	Formed of a set of glands
Electrochemical pulses are the mean of signal transmission	Chemicals called hormones are the means of signal transmission
Signal transmission is fast but the functions are not prolonged	Signal transmission is slow, but the functions are long lasting
The cells are interconnected and the whole system is continuous	The organs of the whole system are not physically connected yet those are discrete
Use the neurons to transmit the signal	Use the circulatory system to transmit the signal
Nervous uses action potentials to communicate and it occurs quickly	Endocrine uses hormones to communicate and it occurs slowly
Nervous intensity of response depends on frequency modulated system (*number of action potentials per unitof time increases or decreases response*)	Endocrine intensity of response depends on amplitude modulated system (*more hormone secreted makes response greater*)

Nervous System

The nervous system is a complex network of nerves and cells that carry messages to and from the brain and spinal cord to various parts of the body.

The nervous system includes both the Central nervous system and Peripheral nervous system.

- **The Central nervous system** which includes the brain and spinal cord, processes and coordinates all incoming sensory information and outgoing motor commands, and it is also the seat of complex brain functions such as memory, intelligence, learning, and emotion.
- **The Peripheral nervous system** *includes* all neural tissue outside of the central nervous system. It is responsible for providing sensory, or afferent, information to the central nervous system and carrying motor, or efferent, commands out to the body's tissues. Voluntary motor commands, such as moving muscles to walk or talk, are controlled by the somatic nervous system, while involuntary motor commands, such as digestion and heartbeat, are controlled by the autonomic nervous system. **The autonomic nervous system** *is further divided into two systems.* **The sympathetic nervous system**, sometimes called the "*fight or flight*" system, increases alertness, stimulates tissue, and prepares the body for quick responses to unusual situations. In contrast, **the parasympathetic nervous system**, sometimes called the "*rest and repose*" system, conserves energy and controls sedentary activities, such as digestion.



Brain (CSS 1990, 1994)

Brain, portion of the central nervous system contained within the skull. The brain is the control center for movement, sleep, hunger, thirst, and virtually every other vital activity necessary to survival. It also receives and interprets the countless signals that are sent to it from other parts of the body and from the external environment.

The human brain has three major structural components:

1. **The Forebrain:** The forebrain consists of the cerebrum, thalamus, and hypothalamus (part of the limbic system).
2. **Midbrain:** The midbrain consists of the tectum and tegmentum.
3. **Hindbrain:** The hindbrain is made of the cerebellum, pons and medulla. Often the *midbrain*, *pons*, and *medulla* are referred to together as the *brainstem*.

The Forebrain

The forebrain is the largest and most complex part of the brain. It consists of the cerebrum — the area with all the folds and grooves typically seen in pictures of the brain — as well as some other structures beneath it.

The cerebrum contains the information that essentially makes us who we are: our intelligence, memory, personality, emotion, speech, and ability to feel and move. Specific areas of the cerebrum are in charge of processing these different types of information. These are called lobes, and there are four of them: the frontal, parietal, temporal, and occipital.

The cerebrum has right and left halves, called hemispheres, which are connected in the middle by a band of nerve fibers (*the corpus collosum*) that enables the two sides to communicate. Though these halves may look like mirror images of each other, many scientists believe they have different functions. The left side is considered the logical, analytical, objective side. The right side is thought to be more intuitive, creative, and subjective. So when you're balancing the checkbook, you're using the left side; when you're listening to music, you're using the right side. It's believed that some people are more *"right-brained"* or *"left-brained"* while others are more "whole-brained," meaning they use both halves of their brain to the same degree.

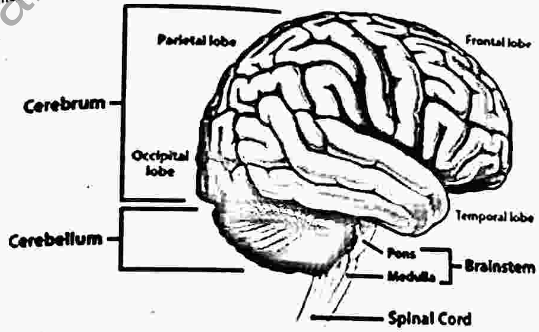
The outer layer of the cerebrum is called the cortex *(also known as "gray matter")*

information collected by the five senses comes into the brain from the spinal cord to the cortex. This information is then directed to other parts of the nervous system for further processing. *For example*, when you touch the hot stove, not only does a message go out to move your hand but one also goes to another part of the brain to help you remember not to do that again

In the inner part of the forebrain sits the thalamus, hypothalamus, and pituitary gland. The thalamus carries messages from the sensory organs like the eyes, ears, nose, and fingers to the cortex. The hypothalamus controls the pulse, thirst, appetite, sleep patterns, and other processes in our bodies that happen automatically. It also controls the pituitary gland, which makes the hormones that control our growth, metabolism, digestion, sexual maturity, and response to stress.

The Midbrain

The midbrain, located underneath the middle of the forebrain, acts as a master coordinator for all the messages going in and out of the brain to the spinal cord. Midbrain/ Mesencephalon- the rostral part of the brain stem, which includes the tectum and tegmentum. It is involved in functions such as vision, hearing, eye movement, and body movement. The anterior part has the cerebral peduncle, which is a huge bundle of axons traveling from the cerebral cortex through the brain stem and these fibers (*along with other structures*) are important for voluntary motor function.



The Hindbrain

The hindbrain sits underneath the back end of the cerebrum, and it consists of the cerebellum, pons, and medulla. The cerebellum — also called the "little brain" because it looks like a small version of the cerebrum — is responsible for balance, movement, and coordination

The *pons* and *the medulla*, along with the midbrain, are often called the *brainstem*. The brainstem takes in, sends out, and coordinates all of the brain's messages. It also controls many of the body's automatic functions, like breathing, heart rate, blood pressure, swallowing, digestion, and blinking.

The Spinal Cord

The spinal cord, on the other hand, is a long bundle of nerve tissue about 18 inches long

and ¾ inch thick. It extends from the lower part of the brain down through spine. Along the
various nerves branch out to the entire body. These make up the peripheral nervous system.
The spinal cord is composed of a series of 31 segments. A pair of spinal nerves co
out of each segment. The region of the spinal cord from which a pair of spinal nerves origin
is called the spinal segment. Both motor and sensory nerves are located in the spinal cord.
The spinal cord is about 43 cm long in adult women and 45 cm long in adult men a
weighs about 35-40 grams. It lies within the vertebral column, the collection of bones (back bon
The peripheral nervous system

The Peripheral Nervous System

The Peripheral Nervous System includes all neural tissue outside of the central nerv
The Peripheral Nervous System is responsible for providing sensory, or afferent, information to the central nerv
system. It is responsible for providing sensory, or afferent, commands out to the body's tissues. Voluntary m
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situations. In contrast, the parasympathetic nervous system, sometimes called the "rest a
repose" system, conserves energy and controls sedentary activities, such as digestion.

Neuron Structure

A neuron (*also known as a neurone, nerve cell or brain cell*) is an electrically excitab
cell in our brain that processes and transmits information by electrical and chemical signalin
Neurons connect to each other to form neural networks

Neurons share the same characteristics and have the same makeup as other cells, excep
they have synapses, and an electrochemical aspect. This electrochemical aspect lets the neur
transmit signals over long distances (*up to several feet or a few meters*) and send messages
other neurons.

Neurons pass messages to each other using their special type of electrical signal. Some
these signals bring information to the brain from outside of your body, such as the things you s
hear and smell. Other signals are instructions for your organs, glands and muscles.

Neurons are the core components of the nervous system, which includes the brain, spi
cord, and peripheral ganglia.

- Neurons are some of the longest cells in our bodies and have shapes and sizes like
others.
- The average number of neurons in the brain = 100 billion
- There are 186 million MORE neurons on Left Side than the Right Side of the hum
brain

The three basic parts of a neuron:

- **Cell body** *or* **Soma.** This main part has all of the necessary components of the cell, su
as the nucleus (which contains DNA), endoplasmic reticulum and ribosomes (*for buildi
proteins*) and mitochondria (*for making energy*). If the cell body dies, the neuron dies.
- **Axon.** This long, cable like projection of the cell carries the electrochemical messa
(*nerve impulse or action potential*) along the length of the cell. Depending upon the
of neuron, axons can be covered with a thin layer of myelin sheath, like an insul
electrical wire. Myelin is made of fat and protein, and it helps to speed transmission o

nerve impulse down a long axon. Myelinated neurons are typically found in the
peripheral nerves (*sensory and motor neurons*), while non-myelinated neurons are found
in the brain and spinal cord.

- **Dendrites** *or* **Nerve Endings.** These small, branchlike projections of the cell make
connections to other cells and allow the neuron to talk with other cells or perceive the
environment. Dendrites can be located on one or both ends of a cell.Neurons receive
signals from neighbor neurons through their dendrites.

Basic Neuron Types

Neurons come in many sizes. For example, a single sensory neuron from your fingertip has an axon that extends the length of your arm, while neurons within the brain may extend only a few millimeters.

Neurons have different shapes depending on what they do

- **Sensory neurons** carry signals from the outer parts of your body (*periphery*) into the central nervous system.
- **Motor Neurons** (*motoneurons*) carry signals from the central nervous system to the outer parts (*muscles, skin, glands*) of your body.
- **Receptors** sense the environment (*chemicals, light, sound, touch*) and encode this information into electrochemical messages that are transmitted by sensory neurons.
- **Interneurons** connect various neurons within the brain and spinal cord.

Neuronal Types

Motor neurons

These lower motor neurons are located on the ventral aspect of the cord. They are either alpha or gamma cells.

- Alpha cells are the principle lower motor neurons of the spinal cord and form the main portion of the final common pathway. They conduct rapid motor impulses, with each alpha cell innervating approximately 200 muscle fibers.
- Gamma neurons are also part of the final common pathway according to some sources but they are only half as numerous as alpha cells. Gamma cells conduct slow motor impulses. Their major function is to stretch muscle spindles.

Association neurons

Interneurons connect the anterior and posterior horns of the gray matter and are involved in the reflex arc. They work within the same segment of the spinal cord, with a segment being defined as the horizontal section of the cord that gives rise to one pair of spinal nerves. Intern uncial Neurons travel between segments, sending projections up to the brain stem and cerebellum. They project in an ascending, not descending manner.

These association neurons are found throughout the central nervous system. They are much more numerous than motor neurons; the ratio between the two types of cells is 30:1.

The main function of the association neurons in the spinal cord is that of inhibitory control. They also interconnect other cells with one another.

Synapses

Where two neurones meet, there is a tiny gap called a synapse. Signals cross this gap using chemicals released by a neurone this chemical as the neurotransmitter called *acetylcholine*. The chemical diffuses across the gap makes the next neurone transmit an electrical signal.

Synapse Structure

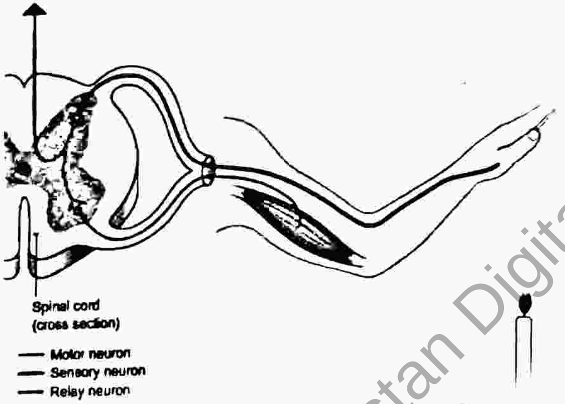
- The part of the synapse that belongs to the initiating neuron is called the *presynaptic* *membrane.*

- The part of the synapse that belongs to the receiving neuron is called the *postsynaptic membrane.*
- The space between the two is called the *synaptic cleft*. It is approximately 20 nm wide (2 x 10^{-9} m).
- Presynaptic terminals contain numerous *synaptic vesicles*
- Synaptic vesicles contain *Neurotransmitters*, chemical substances which ultimately cause postsynaptic changes in the receiving neuron, is contained within the synaptic vesicles.

Common neurotransmitters include:

- *Acetylcholine*
- *Dopamine*
- *Norepinepherine (a.k.a., noradrenaline)*
- *Serotonin*

Reflex Action



When a receptor is stimulated, it sends a signal to the central nervous system, where the brain co-ordinates the response. But, sometimes a very quick response is needed, one that does not need the involvement of the brain. This is a reflex action.

Reflex actions are rapid and happen without us thinking.

For example, you would pull your hand away from a hot flame without thinking about it.

This is what happens:

1. Receptor detects a stimulus - change in the environment
2. Sensory neurone sends signal to relay neurone
3. Motor neurone sends signal to effector
4. Effector produces a response

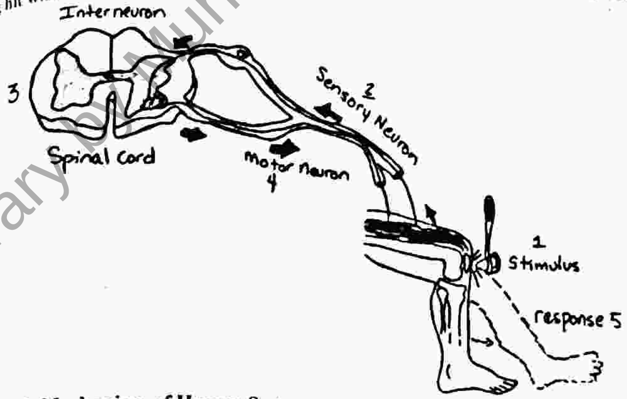
Dynamic Equilibrium and Feedback

Homeostasis is the maintenance of a stable internal state within an organism.

Homeostasis is also known as *steady state*. Organisms must respond and maintain homeostasis in relation to many factors.

Organisms detect changes in their environment and respond to these changes in a variety of ways. These changes may occur at the cellular or organism level.

The graphic below shows the response of a human to being struck on the knee with a hammer. A change in the environment is called a **stimulus**. In this situation, the stimulus is the being struck with the hammer. A *response* is the manner in which the organism reacts to the stimulus. The knee jerk reflex which is pictured at the right is the response of this individual to being hit with this hammer.



Feedback Mechanism of Human System

Feedback mechanisms have evolved in living things as a mechanism by which they maintain *homeostasis* or *dynamic equilibrium*

A *feedback mechanism* occurs when the level of one substance influences the level of another substance or activity of another organ

An example of a feedback mechanism in humans would be the increase in heart rate and respiratory rate which occurs in response to increased exercise or other increased muscle cell activity.

Disorders *of* Central Nervous System

A central nervous system (CNS) disease can affect either the brain or the spinal cord, resulting in neurological or psychiatric disorders. Causes of CNS diseases are trauma, infections, degeneration, autoimmune disorders, structural defects, tumors, and stroke.

Brain Tumor

A brain tumor is an abnormal growth of tissue in the brain. The tumor can either originate in the brain itself, or come from another part of the body and travel to the brain (metastasize).

Brain tumors may be classified as either **benign** (*non-cancerous*) or **malignant** (*cancerous*), depending on their behavior.

- A **Benign tumor** does not contain cancer cells and usually, once removed, does not recur. Most benign brain tumors have clear borders, meaning they do not invade surrounding tissue. These tumors can, however, cause symptoms similar to cancerous tumors because of their size and location in the brain.

- **Malignant brain tumors** contain cancer cells. Malignant brain tumors are usually fast growing and invade surrounding tissue. Malignant brain tumors very rarely spread to other areas of the body, but may recur after treatment. Sometimes, brain tumors that are not cancer are called malignant because of their size and location, and the damage they can do to vital functions of the brain.

Epilepsy *and* Seizures

Epilepsy is a neurological condition involving the brain that makes people more susceptible to having seizures. It is one of the most common disorders of the nervous system

When a person has two or more seizures, he or she is considered to have epilepsy. There are many possible causes of epilepsy, including tumors, strokes, and brain damage from illness or injury. In many cases, there may be no detectable cause for epilepsy.

- *What is Seizures?* The brain is the center that controls and regulates all voluntary and involuntary responses in the body. It consists of nerve cells that normally communicate with each other through electrical activity. A seizure occurs when part(s) of the brain receives a burst of abnormal electrical signals that temporarily interrupts normal electrical brain function

Meningitis

Meningitis and encephalitis are inflammatory diseases of the membranes that surround the brain and spinal cord and are caused by bacterial or viral infections. Viral meningitis is sometimes called aseptic meningitis to indicate it is not the result of bacterial infection and cannot be treated with antibiotics. Symptoms of encephalitis include sudden fever, headache, vomiting, heightened sensitivity to light, stiff neck and back, confusion and impaired judgment, drowsiness, weak muscles, a clumsy and unsteady gait, and irritability. Symptoms that might require emergency treatment include loss of consciousness, seizures, muscle weakness, or sudden severe dementia.

Endocrine System

(CSS 1990, 1999, 2001, 2002, 2003, 2007)

The endocrine system is instrumental in regulating mood, growth and development, tissue function, and metabolism, as well as sexual function and reproductive processes.

In general, the endocrine system is in charge of body processes that happen slowly, such as cell growth. Faster processes like breathing and body movement are controlled by the nervous system. But even though the nervous system and endocrine system are separate systems, they often work together to help the body function properly.

A gland is a group of cells that produces and secretes, or gives off, chemicals. A gland selects and removes materials from the blood, processes them, and secretes the finished chemical product for use somewhere in the body. Glands include two types: *endocrine* and *exocrine*.

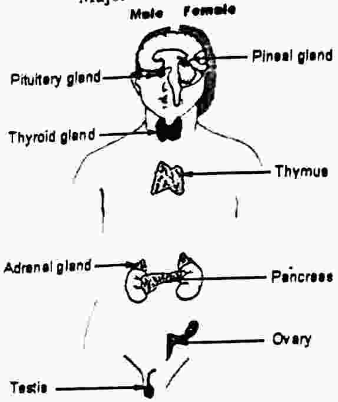
A Comparison *of* Endocrine *and* Exocrine Glands:

Endocrine Glands	**Exocrine Glands**
Endocrine glands do not have ducts.	Exocrine glands have ducts that carry their secretions to specific locations.
Intracellular effects such as altering target cell metabolism	Extracellular effects (food digestion)
Endocrine gland is a gland whose secretions (called hormones) are collected by the blood and reach the tissues through the circulation.	Exocrine gland is a gland whose secretions are released externally through ducts (into the skin, intestinal lumen, mouth, etc.).
The hypophysis (pituitary) and the adrenals are examples of endocrine glands.	The sebaceous glands and the salivary glands are examples of exocrine glands.
Endocrine glands are located throughout the body and each contains a group of specialized cells that secrete hormones in response to body signals.	Exocrine glands usually secrete substances that serve a protective or functional purpose, not always 100% hormones

What are Hormones?

A *hormone* (*from Greek "ὁρμή" - "impetus"*) is a chemical released by one or more cells that affects cells in other parts of the organism. Only a small amount of hormone is required to alter cell metabolism. It is essentially a chemical messenger that transports a signal from one cell to another. All multicellular organisms produce hormones; plant hormones are also called phytohormones. Hormones in animals are often transported in the blood. Cells respond to a hormone when they express a specific receptor for that hormone. The hormone binds to the receptor protein, resulting in the activation of a signal transduction mechanism that ultimately leads to cell type-specific responses.

Major Endocrine Glands



Hypothalamus

The *hypothalamus* is a part of the *brain* located superior and anterior to the brain stem and inferior to the *thalamus*. It serves many different functions in the *nervous system*, and is also responsible for the direct control of the endocrine system through the pituitary gland. The hypothalamus contains special cells called neurosecretory cells—neurons that secrete hormones

Pituitary Gland

The *pituitary gland*, also known as the *hypophysis*, is a small pea-sized lump of tissue connected to the inferior portion of the hypothalamus of the brain. Many *blood vessels* surround the pituitary gland to carry the hormones it releases throughout the body. Situated in a small depression in the *sphenoid bone* called the sella turcica, the pituitary gland is actually made of 2 completely separate structures: the *posterior* and *anterior pituitary* glands.

- *Posterior Pituitary*: The posterior pituitary gland is actually not glandular tissue at all, but nervous tissue instead. The posterior pituitary is a small extension of the hypothalamus through which the axons of some of the neurosecretory cells of the hypothalamus extend. These neurosecretory cells create 2 hormones in the hypothalamus that are stored and released by the posterior pituitary:
  - Oxytocin triggers uterine contractions during childbirth and the release of milk during breastfeeding.
  - Antidiuretic hormone (ADH) prevents water loss in the body by increasing the re-uptake of water in the kidneys and reducing blood flow to sweat glands.
- *Anterior Pituitary*: The anterior pituitary gland is the true glandular part of the pituitary gland. The function of the anterior pituitary gland is controlled by the releasing and inhibiting hormones of the hypothalamus. The anterior pituitary produces 6 important hormones:

1. **Thyroid stimulating** *hormone* (TSH), as its name suggests, is a tropic hormone responsible for the stimulation of the thyroid gland.
2. **Adrenocorticotropic** *hormone* (ACTH) stimulates the adrenal cortex, the outer part of the adrenal gland, to produce its hormones.
3. **Follicle stimulating** *hormone* (FSH) stimulates the follicle cells of the gonads to produce gametes—ova in females and sperm in males.
4. **Luteinizing** *hormone* (LH) stimulates the gonads to produce the sex hormones—estrogens in females and testosterone in males.
5. **Human growth** *hormone* (HGH) affects many target cells throughout the body by stimulating their growth, repair, and reproduction.
6. **Prolactin** (PRL) has many effects on the body, chief of which is that it stimulates the *mammary glands* of the breast to produce milk.

Pineal Gland

The *pineal gland* is a small pinecone-shaped mass of glandular tissue found just posterior to the thalamus of the brain. The pineal gland produces the hormone melatonin that helps to regulate the human sleep-wake cycle known as the circadian rhythm. The activity of the pineal gland is inhibited by stimulation from the photoreceptors of the retina. This light sensitivity causes melatonin to be produced only in low light or darkness. Increased melatonin production causes humans to feel drowsy at nighttime when the pineal gland is active.

Thyroid Gland

The *thyroid gland* is a butterfly-shaped gland located at the base of the neck and wrapped around the lateral sides of the trachea. The thyroid gland produces 3 major hormones:

- Calcitonin
- Triiodothyronine (T3)
- Thyroxine (T4)

Calcitonin is released when calcium ion levels in the blood rise above a certain set point. Calcitonin functions to reduce the concentration of calcium ions in the blood by aiding the absorption of calcium into the matrix of bones. The hormones T3 and T4 work together to regulate the body's metabolic rate. Increased levels of T3 and T4 lead to increased cellular activity and energy usage in the body

Parathyroid Glands

The *parathyroid glands* are 4 small masses of glandular tissue found on the posterior side of the thyroid gland. The parathyroid glands produce the hormone parathyroid hormone (PTH), which is involved in calcium ion homeostasis. PTH is released from the parathyroid glands when calcium ion levels in the blood drop below a set point. PTH stimulates the osteoclasts to break down the calcium containing bone matrix to release free calcium ions into the bloodstream. PTH also triggers the kidneys to return calcium ions filtered out of the blood back to the bloodstream so that it is conserved.

Adrenal Glands

Adrenal glands (*also known as suprarenal glands*) are important endocrine glands of human body. They are two in number, one lying on the upper pole of each kidney. They are yellowish in color and are surrounded by renal fascia. The combined weight of the adrenal glands in an adult human ranges from 7 to 10 grams. An adrenal gland is made of two parts: the outer region is called the *adrenal cortex* and the inner region is called the *adrenal medulla*.

- *The adrenal cortex*, the outer portion of the adrenal gland, secretes hormones that have an effect on the body's metabolism, on chemicals in the blood, and on certain body characteristics. The adrenal cortex secretes corticosteroids and other hormones directly into the bloodstream. The hormones produced by the adrenal cortex

- *The adrenal medulla* produces the hormones epinephrine and norepinephrine under stimulation by the sympathetic division of the autonomic nervous system. Both of these hormones help to increase the flow of blood to the brain and muscles to improve the "fight-or-flight" response to stress. These hormones also work to increase heart rate, breathing rate, and blood pressure while decreasing the flow of blood to and function of organs that are not involved in responding to emergencies.

Pancreas

The pancreas is a lobular, pinkish-grey organ that lies behind the stomach. Its head communicates with the duodenum and its tail extends to the spleen. The organ is approximately 15cm in length with a long, slender body connecting the head and tail segments.

The pancreas has both exocrine and endocrine functions. Endocrine refers to production of hormones which occurs in the Islets of Langerhans. The Islets produce insulin, glucagon and other substances and these are the areas damaged in diabetes mellitus. The exocrine (secretory) portion makes up 80-85% of the pancreas and is the area relevant to the gastrointestinal tract.

Gonads

The gonads—ovaries in females and testes in males—are responsible for producing the sex hormones of the body. These sex hormones determine the secondary sex characteristics of adult females and adult males.

- *Ovaries*: The **ovaries** are a pair of almond-shaped glands located in the pelvic body cavity lateral and superior to the uterus in females. The ovaries produce the female sex hormones *progesterone* and *estrogens*.

Testicles *(testes)*

Testicles (testes) are male sex glands that produce sperm and sex hormones. Usually, both testicles are located in the scrotum. Testosterone is the most important androgen (male sex hormone) in men and it is needed for normal reproductive and sexual function. Testosterone is important for the physical changes that happen during male puberty and for the features typical of adult men such as facial and body hair. Testosterone also acts on cells in the testes to make sperm. Testosterone is also important for overall good health. It helps the growth of bones and muscles, and it affects mood (sex drive) and certain aspects of mental ability.

Major Hormones: Origin, Target, Function

Hormone	Gland Origin	Target Tissu	Function
Adrenocorticotropic	Pituitary gland (anterior)	Adrenal cortex	Triggers secretion of hydrocortisone from the adrenal gland
Growth hormone	Pituitary gland (anterior)	Throughout body	Stimulates growth and development
Follicle-stimulating hormone	Pituitary gland (anterior)	Sex glands	Stimulates female egg maturation and male sperm production
Luteinizing hormone	Pituitary gland (anterior)	Sex glands	Stimulates female ovulation and male secretion of testosterone
Prolactin	Pituitary gland (anterior)	Mammary glands	Stimulates milk production in the breasts after childbirth

Thyroid-stimulating hormone	Pituitary gland (anterior)	Thyroid gland	Triggers secretion of thyroid hormones
Melanocyte-stimulating hormone	Pituitary gland (anterior)	Melanin-producing cells	Controls skin pigmentation
Antidiuretic hormone	Pituitary gland (posterior)	Kidneys	Regulates water retention and blood pressure
Oxytocin	Pituitary gland (posterior)	Uterus Mammary glands	Triggers contraction of the uterus during labor Stimulates milk letdown for breast-feeding after childbirth
Calcitonin	Thyroid gland	Bones	Controls the level of calcium in the blood by depositing it in the bones
Thyroid hormone	Thyroid gland	Throughout body	Increases the body's metabolic rate; promotes normal growth and development
Parathyroid hormone	Parathyroid glands	Bones, intestines, and kidneys	Regulates calcium level in blood
Thymosin	Thymus	White blood cells	Promotes the growth and development of white blood cells, helping the body fight infection
Aldosterone	Adrenal gland	Kidneys	Regulates sodium and potassium levels in the blood to control blood pressure
Hydrocortisone	Adrenal gland	Throughout body	Plays key role in stress response; increases blood glucose levels and mobilizes fat stores; reduces inflammation
Epinephrine	Adrenal gland	Muscles and blood vessels	Increases blood pressure, heart and metabolic rate, and blood sugar levels; dilates blood vessels. Also released during exercise
Norepinephrine	Adrenal gland	Muscles and blood vessels	Increases blood pressure and heart rate; constricts blood vessels
Glucagon	Pancreas	Liver	Stimulates the breakdown of glycogen (stored carbohydrate) into glucose (blood sugar); regulates glucose blood level
Insulin	Pancreas	Throughout body	Regulates blood glucose levels; increases storage of glycogen; facilitates glucose intake by body cells
Estrogen	Ovaries	Female reproductive system	Causes sexual development and growth; maintains proper functioning of female reproductive system
Progesterone	Ovaries	Mammary glands Uterus	Prepares uterus for pregnancy
Testosterone	Testes	Throughout body	Causes sexual development and growth spurt; maintains proper functioning of male reproductive system
Erythropoietin	Kidney	Bone Marrow	Produces red blood cells

Respiratory System

Respiration is defined as the catabolic biochemical process during which organic compounds break down in order to release energy. The organic compounds that are broken down are called the substrates. Glucose is the most common substrate.

All living creatures need food. The food is consumed so that energy is obtained. The energy is utilised by the body for various purposes like locomotion, conduction of impulses, repair of damaged tissues, building of cell materials, etc.

The substance that is used to release energy is called the substrate. The food consumed has various chemical compounds such as carbohydrates, proteins, fats, etc. All these can be used by the body to give energy. Essentially, the body has a mechanism by which the food can be broken down into simpler molecules and in the process, release energy. The most common substrate for respiration is glucose.

Glucose breaks down in the presence of oxygen and gives carbon dioxide, water and energy. The energy is stored in the form of molecules called ATPs. They can be transported to the site of energy utilisation.

Thus, Respiration can be broadly defined as "the breakdown of organic compounds into simpler compounds accompanied by the release of energy in the form of ATP"
Since most often the substrate is glucose, the general equation for respiration can be written as follows

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \textbf{Energy released}$$

Glucose + Oxygen -> Carbon dioxide + water + Energy released

Respiration Cycle

Respiratory System, in anatomy and physiology, organs that deliver oxygen to the circulatory system for transport to all body cells. Oxygen is essential for cells, which use this vital substance to liberate the energy needed for cellular activities. In addition to supplying oxygen, the respiratory system aids in removing of carbon dioxide, preventing the lethal buildup of this waste product in body tissues. Day-in and day-out, without the prompt of conscious thought, the respiratory system carries out its life-sustaining activities. If the respiratory system's tasks are interrupted for more than a few minutes, serious, irreversible damage to tissues occurs, followed by the failure of all body systems, and ultimately, death.

While the intake of oxygen and removal of carbon dioxide are the primary functions of the respiratory system, it plays other important roles in the body. The respiratory system helps regulate the balance of acid and base in tissues, a process crucial for the normal functioning of cells. It protects the body against disease-causing organisms and toxic substances inhaled with air. The respiratory system also houses the cells that detect smell, and assists in the production of sounds for speech.

The respiratory and circulatory systems work together to deliver oxygen to cells and remove carbon dioxide in a two-phase process called respiration.

- **The first phase of respiration** begins with breathing in, or inhalation. Inhalation brings air from outside the body into the lungs. Oxygen in the air moves from the lungs through blood vessels to the heart, which pumps the oxygen-rich blood to all parts of the body. Oxygen then moves from the bloodstream into cells, which completes the first phase of respiration. In the cells, oxygen is used in a separate energy-producing process called cellular respiration, which produces carbon dioxide as a byproduct.
- **The second phase of respiration** begins with the movement of carbon dioxide from the cells to the bloodstream. The bloodstream carries carbon dioxide to the heart, which pumps the carbon dioxide-laden blood to the lungs. In the lungs, breathing out, or exhalation, removes carbon dioxide from the body, thus completing the respiration cycle.

Difference *between* Respiration *and* Breathing

Both breathing and respiration are required for all living organisms. Generally, breathing and respiration are often considered the same. Â However, there is a great difference between these two words

Respiration	**Breathing**
Respiration is a chemical process.	Breathing is a mechanical process
Respiration is the process of breaking down of nutrients with oxygen to produce energy.	Breathing is mainly the bulk exchange of gases in and out of the body
Respiration takes place in cellular level	Breathing occurs between body and external environment
Respiration is only an active process	Breathing involves both active and passive processes
Respiration is always an involuntary process	Breathing is both voluntary and involuntary
Respiration produces energy and waste products	Nothing except gas exchange in breathing

Lung

In human beings, the respiratory organs are the lungs

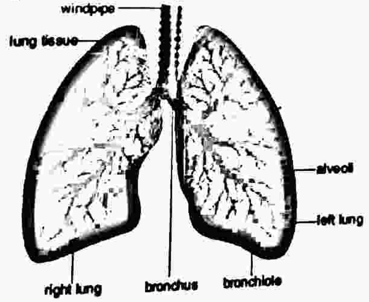
There are a pair of lungs in the thoracic cavity - the left lung and the right lung. The left lung is slightly smaller (because of the heart which is slightly to the left of the body) and has two lobes and the right lung is bigger with three lobes

The lungs also have blood vessels that are the branches of the pulmonary artery and veins.

Each lung is enclosed by two membranes called the outer and the inner pleural membrane. The membranes enclose a space called the pleural cavity that contains a fluid. The lungs are capable of expanding and contracting as they are elastic organs. Lubrication for their free movement is provided by the fluid in the pleural cavity

Respiratory Tract

Apart from the lungs, there are several associated organs and structures which together form the respiratory system. The respiratory system is closely linked with the circulatory system as the transport of the gases takes place through blood.



Structure

The respiratory system starts with the *nose* that encloses the *nasal cavity*. The nasal cavity opens outside through the openings called the *nostrils*. The nasal cavity is divided into two portions by a cartilaginous septum and is lined by fine hairs that filter the dust particles from the air. The nasal cavity is separated from the mouth by hard and soft palate that form its floor. It opens into the region called the *pharynx*.

Pharynx

Pharynx is common to both food and air. This allows more air whenever required and also allows passage of air in case the nose is blocked. Pharynx continues into *glottis*. Glottis is the narrow opening into the larynx. It is guarded by a flap of tissue called the **epiglottis**. Several folds of elastic connective tissue are embedded into the posterior end of the glottis. They are called the **vocal cords**. These extend into the larynx.

Larynx

Larynx is also called the *voice box*. The vocal cords stretch across the larynx and vibrate when the air passes through them. This vibration produces various sounds.

The respiratory tract also helps in the production of sound. The portion of the tract that carries out this function is the larynx or the voice box. It has several folds of elastic connective tissue called the vocal cords. They extend from the posterior end of the pharynx to the end of larynx. When air passes through the larynx, these cords vibrate and produce sound.

The co-ordinated movement of the lips, cheeks, tongue and the jaws produce specific sounds which result in speech. Speech is an ability that only humans are gifted with and this is one of the characteristics which has put human beings at the top of the evolutionary tree.

Larynx continues as the trachea after the cords

Trachea

Trachea is also called the *windpipe*. The tracheas are held open with the help of C-shaped cartilaginous rings. The open ends of the rings are towards the esophagus also known as the food pipe. The trachea is situated in front of the esophagus. The cartilages keep the larynx and trachea from collapsing even when there is no air in them. The trachea then branch into two main branches called *bronchi*.

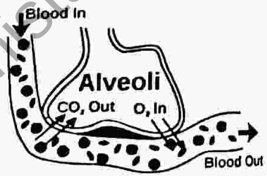
Bronchi

Each *bronchus* is also supported by the cartilaginous rings. The bronchus then branches into several *bronchioles*. The bronchioles progressively lose the cartilages as they become narrower. The bronchioles end as fine tubules called the *alveolar ducts*.

Alveoli

Each *alveolar duct* opens into an alveolar sac. *Alveolar sac* is the extended region into which a group of alveoli or air sacs open.

Each *alveolus* is a sac-like structure lined by a single layer of epithelial cells. It is bound on the outside by a network of capillaries. All the alveoli on one side are enclosed by the membrane called the pleural membrane and constitute a lung.



The pulmonary artery from the heart containing impure blood enters the lungs and branches into minute capillaries which surround the alveoli. These then join together to form the pulmonary vein which carries the purified blood back to the heart

Path Taken by Inhaled Air

The composition of air that we breathe in is:

Nitrogen	78%
Oxygen	21%
Carbon dioxide	0.03 - 0.04%
Hydrogen	traces
Noble gases	traces

Thus the air naturally contains more oxygen than carbon dioxide. This oxygen-rich air is taken in by the nostrils. In the nasal cavity, it is filtered by the fine hair. The cavity also has a rich supply of blood vessels that keep the air warm. This air then enters the pharynx, then the larynx and then into the trachea.

The trachea and the bronchi are lined with ciliated epithelial cells and secretory cells (goblet cells). The secretory cells secrete mucus which moistens the air as it passes through the repiratory tract and also trap any fine particles of dust or bacteria that have escaped the hairs of the nasal cavity. The cilia beat with an upward motion such that the foreign particles along with the mucus is sent to the base of the buccal cavity from where it may be either swallowed or coughed out.

The air from the bronchus then enters the bronchioles and then the alveoli. The alveoli form the respiratory surface in the humans.

Exchange of Respiratory Gases

The exchange of respiratory gases is through membranes. In lungs, the gases are exchanged between the lungs and the blood capillaries and in the tissues, the gases are exchanged between the cells and the blood surrounding them.

The gases move across the membranes by the process of diffusion. Diffusion depends on the partial pressure of the gas concerned. The gases move from the region of higher partial pressure to the region of lower partial pressure. Further, the partial pressure of one gas is independent of the partial pressure of another gas that is mixed with it. Thus the partial pressure of oxygen and carbon dioxide are independent of each other.

The venous capillaries lining the alveoli have impure blood that has low concentration of oxygen and thus lower partial pressure (P_{O_2} in venous blood is 40mm of Hg). The oxygen of the air in the lungs has higher partial pressure (100mm of Hg) and therefore, easily diffuses into the blood through the thin barrier of the alveolus wall. Similarly since the concentration of carbon dioxide is quite high (46mm of Hg) in the venous blood, the gas easily diffuses out into the alveolar space where the partial pressure of carbon dioxide (P_{CO_2} in venous blood is 40mmof Hg) is lower.

Transport of Gases

Oxygen Transport

Most of the oxygen is transported in a combined state. Some of the oxygen is present in solution in the blood. For each deciliter of blood, 4.6ml oxygen enters the blood in the lungs. Of this only 0.17ml remains in the plasma in the solution form. Remaining enters the red blood cells and combines with the hemoglobin.

The hemoglobin pigment (Hb) has an affinity for oxygen. Oxygen combines with the iron ions (Fe^{2+}) of the Hb molecule. In the arteries lining the lungs, it combines with oxygen and forms HbO_2, oxyhaemoglobin.

$$Hb + O_2 \longrightarrow HbO_2$$

However, in the tissues the partial pressure of oxygen is low as it is constantly being used up. Temperature is higher because of metabolic reactions and the acidity is also high. Under these conditions, the oxyhaemoglobin gives up its oxygen and forms haemoglobin again. More active the tissue is, lesser is the partial pressure of oxygen. Thus more oxygen is released by the oxyhaemoglobin in the more active tissues.

Carbon Dioxide Transport

Carbon dioxide is transported in three different forms - dissolved gas, bicarbonates and carbaminohaemoglobin molecules. About 3.7ml of carbon dioxide enters each 100ml of blood. A small amount in the plasma is transported in the dissolved form. Most of the carbon dioxide enters the red blood cells. Of the gas entering the RBCs. 70% is converted to bicarbonate ions and remaining 30% forms carbaminohaemoglobin.

Formation of Bicarbonates

Carbon dioxide first combines with water to form carboxylic acid in the presence of zinc and an enzyme called the carbonic anhydrase. The carboxylic acid is then split into hydrogen ions and bicarbonate ions. Most of the bicarbonate ions come out of the RBCs and are transported by the blood plasma. The hydrogen ions are absorbed by the haemoglobin.

$$CO_2 + H_2O \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3} \longrightarrow H^+ + \underset{\text{Bicarbonate ion}}{HCO_3^-}$$

In the lungs, the reverse reaction takes place and the haemoglobin gives up the hydrogen ions which combine with the bicarbonate to form the carboxylic acid. This then forms carbon dioxide and water.

$$H^+ + HCO_3^- \longrightarrow H_2CO_3 \longrightarrow H_2O + CO_2$$

Both the reactions are catalyzed by an enzyme called the carbonic anhydrase

Formation of Carbaminohaemoglobin

Some of the carbon dioxide entering the erythrocytes combines with the globin (protein part) of haemoglobin to form carbaminohaemoglobin.

The Breathing System

There are two types of physical movements associated with the gaseous exchange. They are:

- Inspiration *or* inhalation
- Expiration *or* exhalation

Inspiration or inhalation:

During inspiration, the outer intercostal muscles contract, which raises the chest cavity or the ribs. This is accompanied by the lowering of the diaphragm. Together these movements serve to increase the area of the thoracic cavity, which reduces the pressure. The air from outside rushes into the lungs.

Expiration or Exhalation

The inner intercostal muscles contract bringing the ribs back to the original position and the diaphragm is also raised back by the action of the abdominal muscles. This reduces the space in the chest cavity and increases the pressure. This expels the air out of the lungs

Lungs & Respiratory System Problems

The respiratory system is susceptible to a number of diseases, and the lungs are prone to a

wide range of disorders caused by pollutants in the air.

The most common problems of the respiratory system are:

Asthma

Asthma, disorder of the respiratory system in which the passages that enable air to pass into and out of the lungs periodically narrow, causing coughing, wheezing, and shortness of breath. This narrowing is typically temporary and reversible, but in severe attacks, asthma may result in death. (*Ref: Asthma by N. W. Jollyman*)

Common Cold.

Common cold caused by over 200 different viruses that cause inflammation in the upper respiratory tract, the common cold is the most common respiratory infection. Symptoms may include a mild fever, cough, headache, runny nose, sneezing, and sore throat.

Lung Cancer

Lung cancer caused by an abnormal growth of cells in the lungs, lung cancer is a leading cause of death in the United States and is usually caused by smoking cigarettes. It starts in the lining of the bronchi and takes a long time to develop, so it's generally a disease in adults. Symptoms include a persistent cough that may bring up blood, chest pain, hoarseness, and shortness of breath.

Pneumonia

This inflammation of the lungs usually occurs because of bacterial or viral infection. Pneumonia causes fever and inflammation of lung tissue, and makes breathing difficult because the lungs have to work harder to transfer oxygen into the bloodstream and remove carbon dioxide from the blood. Common causes of pneumonia are influenza and infection with the bacterium *Streptococcus pneumoniae*.

Cough

A cough is a symptom of an illness, not an illness itself. There are many different types of cough and many different causes, ranging from not-so-serious to life-threatening. Some of the more common causes affecting kids are the common cold, asthma, sinusitis, seasonal allergies, croup, and pneumonia. Among the most serious causes of cough are tuberculosis (TB) and whooping cough (pertussis).

Digestive System

Food is our fuel, and its nutrients give our bodies' cells the energy and substances they need to operate. But before food can do that, it must be digested into small pieces the body can absorb and use. The digestive system has three main functions. First, it breaks down food into molecules the body can use. Then, the molecules are absorbed into the blood and carried throughout the body. Finally, wastes are eliminated from the body.

The process by which our body breaks down food into small nutrient molecules is called digestion. There are two kinds of digestion—mechanical and chemical. In mechanical digestion, foods are physically broken down into smaller pieces. Mechanical digestion occurs when you bite into a sandwich and chew it into small pieces

In chemical digestion, chemicals produced by the body break foods into their smaller chemical building blocks. For example, the starch in bread is broken down into individual sugar molecules.

Digestive Tract

The digestive system is made up of the *alimentary canal* (also called the *digestive tract*) and the other abdominal organs that play a part in digestion, such as the liver and pancreas. The alimentary canal is the long tube of organs — including the esophagus, stomach, and intestines that runs from the mouth to the anus. An adult's digestive tract is about 30 feet (about 9 meters) long.

How Digestion Works

Digestion begins in the **mouth**, well before food reaches the stomach. When we see, smell, taste, or even imagine a tasty meal, our **salivary glands**, which are located under the tongue and near the lower jaw, begin producing saliva. This flow of saliva is set in motion by a brain reflex that's triggered when we sense food or think about eating. In response to this sensory stimulation, the brain sends impulses through the nerves that control the salivary glands, telling them to prepare for a meal.

As the teeth tear and chop the food, **saliva** moistens it for easy swallowing. A digestive enzyme called **amylase**, which is found in saliva, starts to break down some of the carbohydrates (starches and sugars) in the food even before it leaves the mouth.

Swallowing, which is accomplished by muscle movements in the tongue and mouth, moves the food into the throat, or **pharynx**. The pharynx, a passageway for food and air, is about 5 inches (12.7 centimeters) long. A flexible flap of tissue called the **epiglottis** reflexively closes over the windpipe when we swallow to prevent choking.

From the throat, food travels down a muscular tube in the chest called the **esophagus**. Waves of muscle contractions called **peristalsis** force food down through the esophagus to the stomach. A person normally isn't aware of the movements of the esophagus, stomach, and intestine that take place as food passes through the digestive tract.

At the end of the esophagus, a muscular ring or valve called a **sphincter** allows food to enter the stomach and then squeezes shut to keep food or fluid from flowing back up into the esophagus. The stomach muscles churn and mix the food with acids and enzymes, breaking it into much smaller, digestible pieces. An acidic environment is needed for the digestion that takes place in the stomach. Glands in the stomach lining produce about 3 quarts (2.8 liters) of these digestive juices each day.

Most substances in the food we eat need further digestion and must travel into the intestine before being absorbed. When it's empty, an adult's stomach has a volume of one fifth of a cup (1.6 fluid ounces), but it can expand to hold more than 8 cups (64 fluid ounces) of food after a large meal.

Role of the Intestines

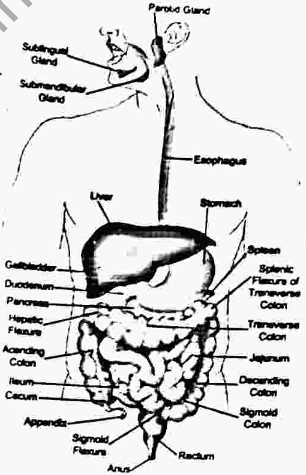
By the time food is ready to leave the stomach, it has been processed into a thick liquid called **chyme**. A walnut-sized muscular valve at the outlet of the stomach called the pylorus keeps chyme in the stomach until it reaches the right consistency to pass into the small intestine. Chyme is then squirted down into the small intestine, where digestion of food continues so the body can absorb the nutrients into the bloodstream.

Small Intestine

The small intestine is made up of three parts:

1. The **Duodenum**, the C-shaped first part
2. The **Jejunum**, the coiled midsection
3. the **Ileum**, the final section that leads into the large intestine

The inner wall of the small intestine is covered with millions of microscopic, finger-like projections called **villi**. The villi are the vehicles through which nutrients can be absorbed into the body.



The **liver** (located under the ribcage in the right upper part of the abdomen), the **gallbladder** (hidden just below the liver), and the **pancreas** (beneath the stomach) are not part of the alimentary canal, but these organs are essential to digestion.

The liver produces bile, which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. The pancreas produces enzymes that help digest proteins, fats, and carbs. It also makes a substance that neutralizes stomach acid. These enzymes and bile travel through special channels (called ducts) directly into the small intestine, where they help to break down food. The liver also plays a major role in the handling and processing of nutrients, which are carried to the liver in the blood from the small intestine.

From the small intestine, undigested food (and some water) travels to the **large intestine** through a muscular ring or valve that prevents food from returning to the small intestine. By the time food reaches the large intestine, the work of absorbing nutrients is nearly finished. The large intestine's main function is to remove water from the undigested matter and form solid waste that can be excreted.

Large Intestine

The large intestine is made up of three parts:

1. The **cecum** is a pouch at the beginning of the large intestine that joins the small intestine to the large intestine. This transition area expands in diameter, allowing food to travel from the small intestine to the large. The **appendix**, a small, hollow, finger-like pouch, hangs at the end of the cecum. Doctors believe the appendix is left over from a previous time in human evolution. It no longer appears to be useful to the digestive process.
2. The **colon** extends from the cecum up the right side of the abdomen, across the upper abdomen, and then down the left side of the abdomen, finally connecting to the rectum. The colon has three parts: the ascending colon; the transverse colon, which absorb fluids and salts; and the descending colon, which holds the resulting waste. Bacteria in the colon help to digest the remaining food products.
3. The **rectum** is where feces are stored until they leave the digestive system through the **anus** as a bowel movement.

Disorders of Digestive System

Diarrhea

Diarrhea describes bowel movements (stools) that are loose and watery. It is ve common and usually not serious. Many people will have diarrhea once or twice each yea typically lasts two to three days and can be treated with over-the-counter (OTC) medicines. So people have diarrhea often as part of irritable bowel syndrome or other chronic diseases of the large intestine.

Hernia

A hernia occurs when an organ or fatty tissue squeezes through a weak spot surrounding muscle or connective tissue called fascia. The most common types of hernia inguinal (inner groin), incisional (resulting from an incision), femoral (outer groin), umbili (belly button), and hiatal (upper stomach).

Constipation

Constipation occurs when bowel movements become difficult or less frequent. Th normal length of time between bowel movements ranges widely from person to person. So people have bowel movements three times a day; others, only one or two times a week. Go longer than three days without a bowel movement is too long. After three days, the stool or fe become harder and more difficult to pass.

Gastritis

Gastritis is an inflammation, irritation, or erosion of the lining of the stomach. It can occ suddenly (acute) or gradually (chronic). If gastritis is left untreated, it can lead to a severe los blood and may increase the risk of developing stomach cancer.

Stomach ulcer

A stomach ulcer (also called a peptic ulcer or a gastric ulcer) is a small erosion (hole) the gastrointestinal tract. The most common type of stomach ulcer is a duodenal ulcer. Duode ulcers occur in the first 12 inches of small intestine beyond the stomach. Ulcers that form in th stomach are called gastric ulcers. An ulcer is not contagious or cancerous. Duodenal ulcers a almost always benign, while stomach ulcers may become malignant.

Appendix

Appendix, a worm-shaped tube branching off the cecum, the first part of the larg intestine. It is located on the lower right side of the abdomen and is usually about 9 cm (about in) long, with a thick wall. Only humans and apes have an appendix.

Symptoms of appendicitis include pain and cramps in the area between the right hip bo and the navel, fever, nausea and vomiting, constipation, and diarrhea. The treatment is surgi removal of the appendix, known as appendectomy. If the appendix wall ruptures, infection ma spread to the abdominal cavity, causing peritonitis, an inflammation of the abdominal lini Acute peritonitis is often fatal if untreated.

Excretory System (CSS 1995, 2000)

Our bodies produce several kinds of wastes, including sweat, carbon dioxide gas, fec (stool), and urine. These wastes exit the body in different ways. Sweat is released through p in the skin. Water vapor and carbon dioxide are exhaled from the lungs. And undigested fo materials are formed into feces in the intestines and excreted from the body as solid waste bowel movements.

Urine, which is produced by the kidneys, contains the byproducts of metabolism — sal toxins, and water — that end up in the blood. The kidneys and urinary tract (which includes kidneys, ureters, bladder, and urethra) filter and eliminate these waste substances from our blo Without the kidneys, waste products and toxins would soon build up in the blood to danger- vels. In addition to eliminating wastes, the kidneys and urinary tract also regulate many portant body functions.

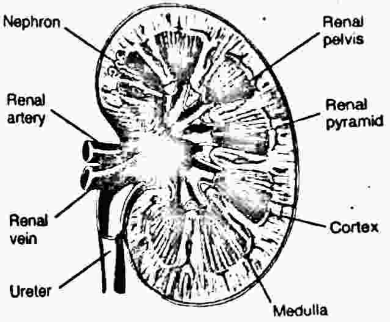
1. The kidneys monitor and maintain the body's balance of water, ensuring that our tissues receive enough water to function properly and be healthy.
2. The kidneys also secrete the hormone erythropoietin, which stimulates and controls red blood cell production (red blood cells carry oxygen throughout the body)
3. The kidneys help regulate the acid-base balance (or the pH) of the blood and body fluids, which is necessary for the body to function normally.
4. The kidneys also regulate blood pressure and the level of vital salts in the blood. By regulating salt levels through production of an enzyme called renin (as well as other substances), the kidneys ensure that blood pressure is regulated.
5. The kidneys help regulate the acid-base balance (or the pH) of the blood and body fluids, which is necessary for the body to function normally.

Structure *of the* Urinary System

Kidneys

The kidneys are dark-red, slightly flattened, bean shaped organs about 10 cm long, 5 cm wide and 4 cm thick. Each adult kidney weighs between 125 and 170 grams in males and between 115 and 155 grams in females. They are placed against the back wall of the abdominal cavity just below the diaphragm, one on either side of the vertebral column, between the last thoracic vertebra and the third lumbar vertebra. They are protected by the last 2 ribs. The kidneys are covered by the peritoneum in the front and on the side and they rest against the abdominal muscles. Their position is slightly asymmetrical, the left kidney being a little higher than the right.

Each kidney is bean shaped. The outer surface is convex and the inner surface is concave. The inner surface has a deep notch called hilus. The ureters, renal artery, renal vein and the nerves enter the kidney through the hilus.



Each kidney is composed of numerous microscopic coiled tubules called nephron or renal tubules or uriniferous tubules. The nephrons are held together by connective tissue, and enveloped by a capsule of white fibrous tissue. Outside the capsule is a layer of fat called the adipose capsule, followed by a membrane called renal fascia. The adipose capsule forms a shock - absorbing cushion and the renal fascia fixes the kidney to the abdominal walls.

The kidney is divided into 2 regions, an outer region called renal cortex and the inner region termed renal medulla. The medulla is subdivided into conical masses, the renal pyramids, each having a broad base towards the cortex and a narrow end called renal papilla towards the pelvis. The renal papilla projects into the wide funnel - like structure called the pelvis. The pelvis leads into the ureter between the pyramids. The cortex extends into the medulla as renal column of Bertin.

Ureters

These are about 28 cm long. They are a pair of narrow, muscular, tubular structures which arise from the hilus of the kidney, run backward along the dorsal body wall and open into the dorsal wall of the urinary bladder. Their wall is made up of a layer of transitional epithelium surrounded by a layer of muscle fibres, followed by a layer of fibrous connective tissue.

Urinary Bladder

It is a pear shaped sac situated in the pelvic region of the abdominal cavity. It has the muscular distensible wall lined by transitional epithelium that allows expansion. It can store about 0.5 to 1 litre of urine. It receives the ureters through the lower part of its back wall. The lower part or neck of the bladder is guarded by 2 rings of muscle fibres called sphincters. Both the sphincters must relax to let urine pass out from the bladder. The act of voiding of urine is called micturition.

Urethra

The urethra starts from the neck of the urinary bladder and leads to the exterior. In females it is about 2 - 3 cm long and carries only urine. It opens by the urethral orifice or urinary aperture in the vulva in front of the vaginal or genital apertur In male, urethra is about 20 cm long and carries urine as well as the spermatic fluid. It passes through the penis and opens out at the tip of the penis by a urinogenital aperture.

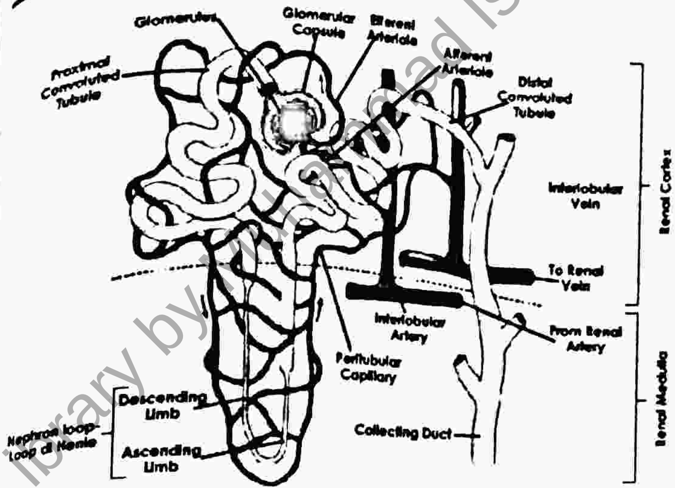
Structure of a Nephron

The nephron or uriniferous tubule is the functional unit of the kidney. A nephron consists of a twisted tubule closed at one end, open at the other with a network of associated blood vessels. Each kidney of man is formed of about one million nephrons. Each nephron has a length of about 3 cm. It is differentiated into 4 regions having different anatomical features and different physiological roles.

The 4 regions are:

1. Bowman's capsule
2. Proximal convoluted tubule (PCT)
3. Loop of Henle
4. Distal convoluted tubule (DCT)

Each of the nephrons contain a filter called the glomerulus, which contains a network of tiny blood vessels known as capillaries. The fluid filtered from the blood by the glomerulus then travels



down a tiny tube-like structure called a tubule, which adjusts the level of salts, water, and wastes that are excreted in the urine.

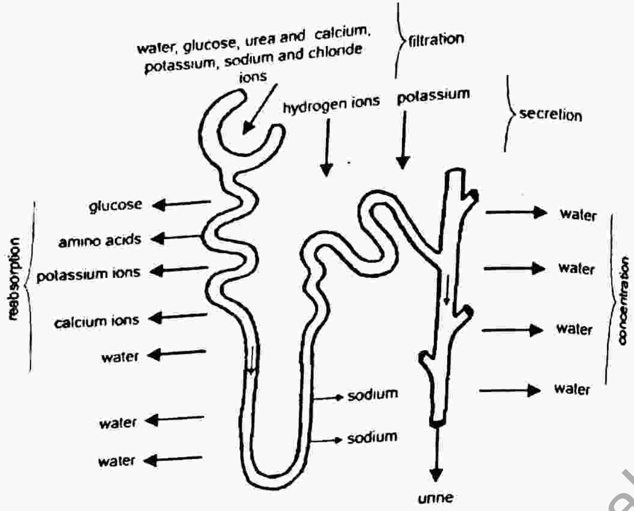
The Formation of Urine

The formation of urine takes place by 3 processes.

1. Ultra filtration or glomerular filtration.
2. Selective reabsorption
3. Tubular secretion

Ultra Filtration *or* Glomerular Filtration

Due to the efferent arterioles being narrower than the afferent arteriole, the blood pressure is twice that in the capillary network. Blood enters the glomerulus at a hydrostatic pressure of 60 mm Hg., to filter out some fine components of blood. The glomerular filteration pressure is about 10 mm Hg and is responsible for filtering a large amount of water, glucose, amino acids, vitamins, Na^+ and a number of harmful substances like urea, uric acid, creatinine, ammonium salts. Pigments, K^+. The proteins, fats and carbohydrates are not filtered out. The glomerular filtrate is same as blood minus cells and proteins. It resembles the protein free plasma in composition and Osmotic pressure.



About 650 ml of blood passes through the glomerular capillaries in all nephrons of both kidneys, but in one minute about 125 ml of filtrate is filtered out. So about 150 - 180 lts of nephric filtrate is formed per day but only 1.5 - 1.8 lts of urine is excreted out per day and this is called urine output

Selective Reabsorption

As the nephric filtrate moves in the nephron towards the collecting tubule, about 99% of water, whole of glucose and amino acids, most of the Na^+ and Cl, some urea and uric acid are reabsorbed back into the blood. This process by which only useful substances are reabsorbed from the nephric filtrate is called selective reabsorption

The PCT actively absorbs almost whole of glucose, 75% of amino acids and Vitamin C about 70% Na^+, about 75% of K^+ and a large amount of Ca^{++} from the glomerular filtrate. The ascending limb of Henle's loop actively reabsorbs about 25% of K^+ and some Cl^- ions. DCT and the collecting tubules actively reabsorb some Na^+ from nephric filtrate in exchange with K^+ of the interstitial fluid

The main function of reabsorption is to maintain homeostasis so that volume, electrolytic balance composition, pH and osmotic pressure of blood are kept constant

Tubular Secretion

The third process by which the kidneys clean or filter blood (regulating its composition and volume) is called tubular secretion and involves substances being added to the tubular fluid This removes excessive quantities of certain dissolved substances from the body and also

maintains the blood at a normal healthy pH level; typically in the range of pH 7.35 to pH 7.45. The substances that are secreted into the tubular fluid for removal from the body include:

- Potassium ions (K+)
- Hydrogen ions (H+)
- Ammonium ions (NH_4+)
- Creatinine
- Urea
- Some hormones
- Some drugs (e.g., penicillin)

As a result of these 3 processes the wastes are changed into urine.

Composition of Urine

The urine is a pale yellow coloured fluid. The yellow colour is due to the presence of urochrome pigment formed from the haemoglobin of dead RBC's in the liver cells. It is acidic in nature and has a pH of 6.0. It has a faint anamalic odour due to the presence of urinod. It soon gets a strong smell of ammonia which forms as a result of degradation of urea. Daily urine output is 1.5 to 1.8 lts. The volume of urine output is directly proportional to the fluid intake. Chemically it is formed of water 95 - 96%, urea 2%, other wastes like uric acid, hip puric acid, createnine, phosphates and oxalates 2-3%. It also contains non-nitrogenous organic compounds like vitamin C, oxalic acid and phenolic substances

Kidney Failure or Renal Failure

A partial or total inability of kidneys to carry on excretion and salt - water regulatory functions is called as kidney or renal failure.

Causes

Kidney failure is caused due to many reasons:

1. Tubular injury
2. Infection
3. Bacterial toxins
4. Inflammation of glomeruli
5. Arterial or venous obstruction
6. Fluid and electrolyte depletion
7. Intrarenal precipitation of calcium and urates.
8. Drug reaction
9. Haemorrhage

Proper maintenance of the normal fluid balance, blood volume and blood pressure can help prevent renal failure

Artificial Kidney

The haemodialyzer or artificial kidney is a machine used to filter the blood of a person whose kidneys are damaged. The process is called haemodialysis. Haemodialysis is defined as the seperation of small molecules from large molecules in a solution by interposing a semipermeable membrane between the solution and water. It works on the principle of dialysis, which is the diffusion of small solute molecules through a semipermeable membrane.

The haemodialyzer consists of a cellophane tube suspended in a salt - water solution of the same composition as the normal blood plasma, but without any urea present in it. Blood of the patient is pumped from one of the arteries into the cellophane tube after cooling it to 0°C and mixing it with an anticoagulant heparin. The pones of the cellophane tube allow urea, uric acid creatinine and excess salts to diffuse from the blood into the surrounding solution.

The blood which is now purified, is warmed to body temperature, mixed with an anti heparin to restore its normal clotting power and is checked to ensure that it is isotonic to the patients' blood. It is then pumped into a vein of the patient. Plasma proteins remain in the blood as the pones of the cellophane are too small to permit the passage of their large molecules.

Disorders Related to Kidney

- **High blood pressure** (or hypertension) can result when the kidneys are impaired by disease. The kidneys control blood pressure by regulating the amount of salt in the body. They also produce the enzyme renin that, along with other substances, controls the constriction of muscle cells in the walls of the blood vessels, which affects a person's blood pressure.
- **Kidney stones** (or nephrolithiasis) result from the buildup of crystallized salts and minerals such as calcium in the urinary tract. Stones (also called calculi) can also form after an infection. If kidney stones are large enough to block the kidney or ureter, they can cause severe abdominal pain. But the stones usually pass through the urinary tract on their own. In some cases, they may need to be removed surgically.
- **Nephritic syndrome** is a type of kidney disease that leads to loss of protein in the urine and swelling of the face (often the eyes) or body (often around the genitals). It is most common in children younger than 6 years old and is more prevalent in boys. Nephrotic syndrome is often treated with steroids.

The Musculoskeletal System

Bones, Muscles and Joints

Skeleton (anatomy), term applied to all the rigid or semirigid structures supporting the soft tissues of an animal's body and providing leverage for muscular action. In vertebrates, the skeleton is known as the endoskeleton and is formed within the body. Some invertebrate animals, such as insects and crustaceans, have skeletons known as exoskeletons on the outside of the body.

Exoskeleton vs Endoskeleton

Exoskeleton	Endoskeleton
Hard part that lies outside of the body is called exoskeleton.	Hard part that lies inside of the body is called endoskeleton.
Develops from ectoderm.	Develops from endoderm.
Mostly non-living e.g. scales, hair, horns, feathers.	They are living, e.g. Bones, cartilages.
Exoskeletal structures may be laminated and then hollowed out to make them ultra lightweight.	Endoskeletal structures, are generally lighter in weight than exoskeletal, particularly when carbon composites and titanium are used
Exoskeletons found in *arthropods* cover the outside of the body but limit size.	*Endoskeletons found in all vertebrates* are *found* inside the body

Some animals, such as the tortoise, have both an endoskeleton and an exoskeleton

The Functions of Skeleton

The skeletal system has 5 primary functions:

1) **Support**: provides structural support for the entire body Bones provide a framework for the attachment of soft tissues and organs

2) **Storage of minerals** (*calcium*) and lipids (*yellow marrow*)

- Calcium salts of bone are important mineral reserves that help maintain normal concentrations of calcium and phosphate ions in body fluids
  - These minerals are important in muscle contraction and nerve activity
  - On demand, bone releases these minerals into the blood to maintain critical mineral balances and to distribute them to other body parts
- Lipids stored in the cells of a type of marrow called yellow bone marrow are important chemical energy reserves
  - Yellow bone marrow consists primarily of adipose cells and a few scattered blood cells

3) **Blood cell production:** Red and white blood cells and platelets are produced within red bone marrow

- Red marrow fills the internal cavities of many bones

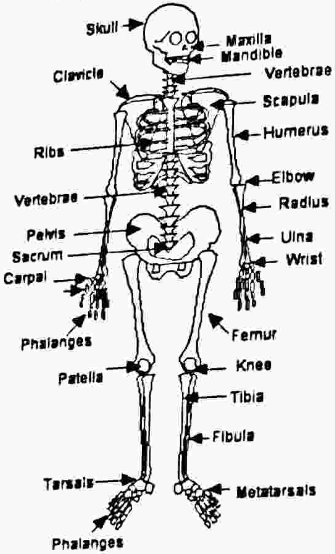
4) **Protection:** skeletal elements often surround soft tissues and organs

- Ex) Ribs protect the heart and lungs, skull encloses the brain, vertebrae shield spinal cord

5) **Leverage** (*movement*): many bones function as levers that change the magnitude and directions of forces generated by skeletal muscles

- Resulting movements range from very slight changes (*motion of a fingertip*) to powerful changes in the position of the entire body

Human Skeleton



The human skeleton has 206 bones, which begin to develop before birth. When the skeleton first forms, it is made of flexible cartilage, but within a few weeks it begins the process of ossification. Ossification is when the cartilage is replaced by hard deposits of calcium phosphate and stretchy collagen, the two main components of bone. It takes about 20 years for this process to be completed.

The bones of kids and young teens are smaller than those of adults and contain "growing zones" called growth plates. These plates consist of columns of multiplying cartilage cells that grow in length, and then change into hard, mineralized bone. These growth plates are easy to spot on an X-ray. Because girls mature at an earlier age than boys, their growth plates change into hard bone at an earlier age.

List of Bones in the Human Body

Here is a list of the various bones, which are grouped as per the part of the body that they are present in.

Bones of the Skull

The human **skull or cranium** is made of 8 bones in all. It houses the brain, and forms a hard, protective covering around this master organ. (Frontal (1) Parietal (2) Temporal (2) Occipital (1) Sphenoid (1) Ethmoid (1) Total number of bones = 8)

Facial Bones

Our face is made up of 14 bones (Mandible (1) Maxilla (2) Palatine bone (2) Zygomatic bone (2) Nasal bone (2) Lacrimal bone (2) Inferior nasal conchae (2) Vomer (1) Total number of bones =14)

Bones of the Middle Ear

The middle ear is the region between the eardrum and the cochlea. In all mammals, including humans, the middle ear has three bones that are known as the auditory ossicles. These are very small bones, and their function is to transmit sound vibrations from the eardrum to the inner ear. (Malleus (2) Incus (2) Stapes (2) Total number of bones = 6)

Bones of the Shoulder Girdle

The shoulder is made of two bones that together allow the attachment of the arm to the body.(Scapula (2) Clavicle (2) Total number of bones = 4)

Bones of the Thorax

The thorax is the part of the body between the neck and the abdomen. It is the portion below the neck that encloses the heart and the lungs (Sternum (1) Ribs (24) Total number of bones = 25)

Bones of the Vertebral Column

The vertebral column, or the spinal column, is made up of 24 small bones, each of which is known as a vertebra. In addition to the vertebrae, there are two other bones that form a part of the vertebral column: the sacrum and the coccyx. The vertebrae give the vertebral column its flexibility due to which we can bend forwards and sideways. (Cervical vertebrae (7) Thoracic vertebrae (12) Lumbar vertebrae (5) Total number of bones=24)

Bones of the Pelvic Girdle

(Hip bone (2) Total number of bones = 2)

Bones of the Hand

The bones of the hands can be divided into those that make up the upper arm, the lower arm, the wrist, the palm and the fingers. The various bones of the hands are as given below. (*Bones at a Glance* Humerus (2) Radius (2) Ulna (2) Carpals (16) Metacarpals (10) Phalanges (28) Total number of bones = 60)

- *Humerus:* This is a single long bone of the upper arm. It runs from the shoulder to the elbow. The humerus connects the scapula to the bones of the forearm.
- *Radius:* Radius is one of the long bones of the forearm that lies on the lateral side of the ulna (*the other bone of the forearm*). Prismatic in shape, it starts from the lateral side of the elbow and continues to the thumb side of the wrist.
- *Ulna:* It is a long bone that runs parallel to the radius, along the forearm. It has a prismatic shape, and lies on the side of the little finger.
- *Carpal Bones:* These are the bones of the wrist. There are 16 carpal bones in all, 8 on each wrist. They are:

Scaphoid bone (2)
Lunate bone (2)
Triquetral bone (2)
Pisiform bone (2)
Trapezium (2)
Trapezoid bone (2)
Capitate bone (2)

Hamate bone (2)

- *Metacarpal Bones*: These are the bones of the palm, and there are 5 metacarpal bones in every palm, one corresponding to each digit.
- *Phalanges:* These are the bones of the fingers. There are 5 proximal phalanges in each hand, and they are located in front of the metacarpals. They are 4 intermediate phalanges in front of the proximal phalanges, one on each finger, except the thumb. The phalanges are located at the tip of each finger, and are known as the distal phalanges. They are 5 in number.

Bones of the Leg

The bones of the legs are those that make up the thigh, the lower half of the legs, and the feet.(Femur (2) Tibia (2) Fibula (2) Patella (2) Tarsals (14) Metatarsals (10) Phalanges (28) Total number of bones = 60)

- *Femur:* This is the longest bone in the human body, and is also known as the thigh bone. *Tibia:* The tibia is the second longest bone in the human body. Along with the fibula forms the lower part of the leg below the knee. The tibia is considered by many to be the strongest bone of the body. It is commonly known as the shin bone.
- *Fibula:* The fibula is a long but thin bone which, along with the tibia, forms the lower part of the human leg. It is attached to the tibia at both the ends. The fibula is also known as the calf bone.
- *Patella:* The patella is a triangular bone that forms a protective cap over the knee joint. Also known as the kneecap, it articulates with the femur (thigh bone). It is the largest sesamoid bone in the human body.
- *Tarsal Bones:* The tarsal bones are the bones of the ankle, and there are 14 tarsal bones on each foot. They are as under.

  Calcaneus (2)
  Talus (2)
  Navicular bone (2)
  Medial cuneiform bone (2)
  Intermediate cuneiform bone (2)
  Lateral cuneiform bone (2)
  Cuboid bone (2)
- *Metatarsal Bones:* There are 5 metatarsal bones in each foot, one corresponding to each digit. These lie between the tarsal bones and the phalanges. *These may be considered to be equivalent to the metacarpal bones of the hands.*
- *Phalanges:* These are bones of the toes of the feet. There are 5 proximal phalanges in each foot. There are 4 intermediate phalanges, one on each finger, except the big toe. The phalanges on the tips of the toes are known as the distal phalanges. They are 5 in number

Muscles *and* their Functions

Bones don't work alone — they need help from the muscles and joints. Muscles pull on the joints, allowing us to move. They also help your body perform other functions so you can grow and remain strong, such as chewing food and then moving it through the digestive system

A conservative estimate of the number of skeletal muscles in the human body is 630.which make up half of a person's body weight. They are connected to bones by tough, cord-like tissues called tendons, which allow the muscles to pull on bones.

Humans have three different kinds of muscle:

1 **Skeletal muscle** is attached to bone, mostly in the legs, arms, abdomen, chest, neck, and face. Skeletal muscles are called striated because they are made up of fibers that have horizontal stripes when viewed under a microscope. These muscles hold the skeleton together, give the body shape, and help it with everyday movements (*known as voluntary muscles because you can control their movement*). They can contract (*shorten or tighten*) quickly and powerfully, but they tire easily and have to rest between workouts.

2 **Smooth, or involuntary, muscle** is also made of fibers, but this type of muscle looks smooth, not striated. Generally, we can't consciously control our smooth muscles; rather, they're controlled by the nervous system automatically (*which is why they're also called involuntary*). Examples of smooth muscles are the walls of the stomach and intestines, which help break up food and move it through the digestive system. Smooth muscle is also found in the walls of blood vessels, where it squeezes the stream of blood flowing through the vessels to help maintain blood pressure.

3. **Cardiac muscle** is found in the heart. The walls of the heart's chambers are composed almost entirely of muscle fibers. Cardiac muscle is also an involuntary type of muscle. Its rhythmic, powerful contractions force blood out of the heart as it beats.

Skeletal Muscle *vs* Smooth Muscle *vs* Cardiac Muscle

Skeletal Muscle

- Directly attached to the skeleton
- Aids movement and locomotion
- Is voluntarily activated
- If you were to view it under a microscope you would see it has a striped appearance which we call "Striated Muscle"
- Fatigues rapidly in comparison to Smooth and Cardiac Muscles
- Is able to stretch and then resume original shape
- Its striated appearance comes from its formation of actin and myosin muscle fibres
- Is capable of powerful muscle contractions and just as adequately small contractions for delicate action requiring precision
- Is stimulated by the nervous system in the form of motor neurons
- The muscle attaches to the skeletal bone by tendons
- Well supplied with nerves and blood vessel

Smooth Muscle

- get its name because it is smooth in appearance if viewed under a microscope, since it is arranged in bundles or sheets of muscle fibres
- contracts involuntarily (Regulated by the autonomic part of the nervous system
- found in the walls of structures within the body, which are generally hollow (i.e. veins, arteries and the intestines)
- one of its key functions is to maintain flow of fluids and foods along its hollow structures
- Main locations of involuntary muscle (Erectors of hairs, Pupils, Ducts of glands, Oesophegas, Bronchi, intestines, stomach and Blood vessels)
- Slow Rhymithical contractions
- Fatigues slowly

Cardiac Muscle

- Found only In the heart and at the cardiac ends of the main blood vessels
- Contracts involuntarily

- If viewed under the microscope it would be striated in appearance
- Doesn't fatigue
- Rhythmic contractions
- Controlled by the central nervous system
- Contractions can occur without signals from nervous system due to "Pacemaker Cell"
- High count of mitochondria
- High count of myoglobin
- Has a good blood supply
- Contrasts and Comparisons

Joints *and* Their Function

Joints occur where two bones meet. They make the skeleton flexible — without them, movement would be impossible.

Joints allow our bodies to move in many ways. Some joints open and close like a hinge (such as knees and elbows), whereas others allow for more complicated movement — a shoulder or hip joint, for example, allows for backward, forward, sideways, and rotating movement.

Joints are classified by their range of movement.

- **Immovable, *or* fibrous, joints** don't move. The dome of the skull, for example, is made of bony plates, which must be immovable to protect the brain. Between the edges of these plates are links, or joints, of fibrous tissue. Fibrous joints also hold the teeth in the jawbone.
- **Partially movable, *or* cartilaginous, joints** move a little. They are linked by cartilage, as in the spine. Each of the vertebrae in the spine moves in relation to the one above and below it, and together these movements give the spine its flexibility.
- **Freely movable, *or* synovial, joints** move in many directions. The main joints of the body — found at the hip, shoulders, elbows, knees, wrists, and ankles — are freely movable. They are filled with synovial fluid, which acts as a lubricant to help the joints move easily.

Three kinds of freely movable joints play a big part in voluntary movement:

1. **Hinge joints** allow movement in one direction, as seen in the knees and elbows.
2. **Pivot joints** allow a rotating or twisting motion, like that of the head moving from side to side.
3. **Ball-*and*-socket joints** allow the greatest freedom of movement. The hips and shoulders have this type of joint, in which the round end of a long bone fits into the hollow of another bone.

Problems *with the* Bones, Muscles *and* Joints

The tissues of the skeletal system are affected by degenerative wear and tear, infectious agents, genetic anomalies, etc. Some of the commonly known diseases, disorders and medical conditions of the skeletal system have been described below.

Arthritis

Arthritis, an inflammation of any joint, is the most common and best known of the joint disorders, affecting 10% of the world's population. Autoimmunity, wear and tear of the joints and associated tissues, and infection are the common causes. Depending on the cause and the tissue affected, about 100 different types have been identified. Osteoarthritis, rheumatoid arthritis and psoriatic arthritis are some of the common types.

Bursitis

It implies the inflammation of fluid-filled sacs called bursae, which serve as a cushion between the bone, and the tendons and/or muscles present in joints. Shoulders, knees, elbows and hips are the commonly affected joints. Such inflammation can occur due to infections, trauma, or aging

Osteoarthritis

It is the result of bone infection, either contracted through another infected organ of the body or after surgeries involving metal plates and rods. It is characterized by severe pain and inflammation in the infected bone, fever, chills, nausea, and weakness. Staphylococcus aureus is the most common causative agent of osteomyelitis

Osteoporosis

It is one of the most common bone diseases, and is characterized by reduction in bone mineral density. It is the result of an imbalance in the bone formation and bone reabsorption process. The bones become weak and tend to get fractured easily.

Poliomyelitis

Also called polio, this disease is highly contagious and infectious and is caused by three types of polio viruses. It affects the nervous system resulting into partial or total paralysis. It is often transmitted through fecal-oral contact. While 90-95% of the people may not show any symptoms, there are some who experience mild symptoms like nausea, fever, decreased appetite, constipation, etc. There are three types of poliomyelitis- Abortive poliomyelitis, Non-paralytic poliomyelitis and Paralytic poliomyelitis.

Tendinitis

Tendons are the tough connective tissue cords between the muscles and bones, which help muscles to move the bones. Tendinitis is the inflammation of the tendons that is caused by the overuse of muscles or due to an injury. It usually affects joints of the knees, hips, elbows, shoulders, heels and wrists. It causes tenderness and pain near these joints. When tendinitis affects the elbow it is given a specific name - Tennis elbow (*Lateral Epicondylitis*).

Human Reproduction

All living things reproduce. Reproduction — the process by which organisms make more organisms like themselves — is one of the things that sets living things apart from nonliving things. But even though the reproductive system is essential to keeping a species alive, unlike other body systems it's not essential to keeping an individual alive.

In the human reproductive process, two kinds of sex cells, or gametes, are involved. The male gamete, or sperm, and the female gamete, the egg or ovum, meet in the female's reproductive system to create a new individual. Both the male and female reproductive systems are essential for reproduction.

Male Reproduction System

Most species have two sexes: male and female. Each sex has its own unique reproductive system. They are different in shape and structure, but both are specifically designed to produce, nourish, and transport either the egg or sperm.

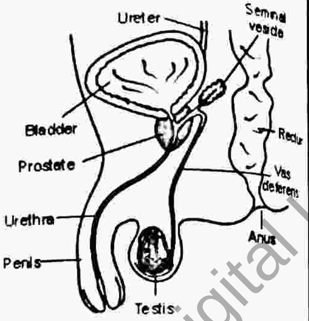
Unlike the female, whose sex organs are located entirely within the pelvis, the male has reproductive organs, or genitals, that are both inside and outside the pelvis. The male genitals include:

- The testicles
- The duct system, which is made up of the epididymis and the vas deferens

- The accessory glands, which include the seminal vesicles and prostate gland
- The penis

In a guy who has reached sexual maturity, the two testicles, or testes, produce and s millions of tiny sperm cells. The testicles are oval-shaped and grow to be about 2 inches centimeters) in length and 1 inch (3 centimeters) in diameter. The testicles are also part of the endocrine system because they produce hormones, including testosterone. Testosterone is hormone that causes boys to develop deeper voices, bigger muscles, and body and facial hair, and it also stimulates the production of sperm.

Alongside the testicles are the epididymis and the vas deferens, which make up the d system of the male reproductive organs. The vas deferens is a muscular tube that passes upward alongside the testicles and transports the sperm-containing fluid called semen. The epididymis a set of coiled tubes (one for each testicle) that connects to the vas deferens.



The epididymis and the testicles hang in a pouch-like structure outside the pelvis called the scrotum. This bag of skin helps to regulate the temperature of testicles, which need to be kept cooler than body temperature to produce sperm. The scrotum changes size to maintain the right temperature. When the body is cold, the scrotum shrinks and becomes tighter to hold in body heat. When it's warm, the scrotum becomes larger and more floppy to get rid of extra heat. This happens without a guy ever having to think about it. The brain and the nervous system give the scrotum the cue to change size.

The accessory glands, including the seminal vesicles and the prostate gland, provide fluids that lubricate the duct system and nourish the sperm. The seminal vesicles are sac-like structures attached to the vas deferens to the side o the bladder. The prostate gland, which produces some of the parts of semen, surrounds th ejaculatory ducts at the base of the urethra, just below the bladder. The urethra is the channel the carries the semen to the outside of the body through the penis. The urethra is also part of the urinary system because it is also the channel through which urine passes as it leaves the bladde and exits the body.

The penis is actually made up of two parts: the shaft and the glans. The shaft is the mai part of the penis and the glans is the tip (*sometimes called the head*). At the end of the glans is a small slit or opening, which is where semen and urine exit the body through the urethra. The inside of the penis is made of a spongy tissue that can expand and contract.

All boys are born with a foreskin, a fold of skin at the end of the penis covering the glans. S me boys are circumcised, which means that a doctor or clergy member cuts away the foreski Circumcision is usually performed during a baby boy's first few days of life. Althoug circumcision is not medically necessary, parents who choose to have their children circumcis often do so based on religious beliefs, concerns about hygiene, or cultural or social reasons. Boy who have circumcised penises and those who don't are no different: All penises work and feel th same, regardless of whether the foreskin has been removed.

Sperm

A male who has reached puberty will produce millions of sperm cells every day. Each sperm is extremely small: only 1/600 of an inch (0.05 millimeters long). Sperm develop in the testicles within a system of tiny tubes called the seminiferous tubules. At birth, these tubules contain simple round cells, but during puberty, testosterone and other hormones cause these cells to transform into sperm cells. The cells divide and change until they have a head and short tail, like tadpoles. The head contains genetic material (genes). The sperm use their tails to push themselves into the epididymis, where they complete their development. It takes sperm about 4 to 6 weeks to travel through the epididymis.

The sperm then move to the vas deferens, or sperm duct. The seminal vesicles and prostate gland produce a whitish fluid called seminal fluid, which mixes with sperm to form semen when a male is sexually stimulated. The penis, which usually hangs limp, becomes hard when a male is sexually excited. Tissues in the penis fill with blood and it becomes stiff and erect (an erection). The rigidity of the erect penis makes it easier to insert into the female's vagina during sexual intercourse. When the erect penis is stimulated, muscles around the reproductive organs contract and force the semen through the duct system and urethra. Semen is pushed out of the male's body through his urethra — this process is called ejaculation. Each time a guy ejaculates, it can contain up to 500 million sperm.

When the male ejaculates during intercourse, semen is deposited into the female's vagina. From the vagina the sperm make their way up through the cervix and move through the uterus with help from uterine contractions. If a mature egg is in one of the female's fallopian tubes, a single sperm may penetrate it, and fertilization, or conception, occurs.

This fertilized egg is now called a zygote and contains 46 chromosomes — half from the egg and half from the sperm. The genetic material from the male and female has combined so that a new individual can be created. The zygote divides again and again as it grows in the female's uterus, maturing over the course of the pregnancy into an embryo, a fetus, and finally a newborn baby.

Female Reproduction System

Unlike the male, the human female has a reproductive system located entirely in the pelvis (that's the lowest part of the abdomen). The external part of the female reproductive organs is called the vulva, which means covering. Located between the legs, the vulva covers the opening to the vagina and other reproductive organs located inside the body.

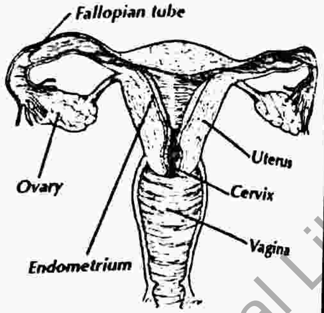
The fleshy area located just above the top of the vaginal opening is called the *mons pubis* Two pairs of skin flaps called the labia (*which means lips and is pronounced:* LAY-bee-uh) surround the vaginal opening. The *clitoris* a small sensory organ, is located toward the front of the vulva where the folds of the labia join. Between the labia are openings to the *urethra* (*the canal that carries urine from the bladder to the outside of the body*), and vagina. Once girls become sexually mature, the outer labia and the mons pubis are covered by pubic hair.

A female's internal reproductive organs are the vagina, uterus, fallopian tubes, and ovaries.

The vagina is a muscular, hollow tube that extends from the vaginal opening to the uterus. The vagina is about 3 to 5 inches (8 to 12 centimeters) long in a grown woman. Because it has muscular walls it can expand and contract. This ability to become wider or narrower allows the vagina to accommodate something as slim as a tampon and as wide as a baby. The vagina's muscular walls are lined with mucous membranes, which keep it protected and moist.

The vagina has several functions: for sexual intercourse, as the pathway that a baby takes out of a woman's body during childbirth, and as the route for the menstrual blood (*the period*) to leave the body from the uterus.

A thin sheet of tissue with one or more holes in it called the *hymen* partially covers the opening of the vagina. The vagina connects with the *uterus*, or womb, at the cervix. The cervix has strong, thick walls. The opening of the cervix is very small (no wider than a straw), which is why a tampon can never get lost inside a girl's body. During childbirth, the cervix can expand to allow a baby to pass.



The uterus is shaped like an upside-down pear, with a thick lining and muscular walls — in fact, the uterus contains some of the strongest muscles in the female body. These muscles are able to expand and contract to accommodate a growing fetus and then help push the baby out during labor. When a woman isn't pregnant, the uterus is only about 3 inches (7.5 centimeters) long and 2 inches (5 centimeters) wide.

At the upper corners of the uterus, the *fallopian* tubes connect the uterus to the *ovaries* The ovaries are two oval-shaped organs that lie to the upper right and left of the uterus. They produce, store, and release eggs into the fallopian tubes in the process called *ovulation* Each ovary measures about 1½ to 2 inches (4 to 5 centimeters) in a grown woman.

There are two fallopian tubes, each attached to a side of the uterus. The fallopian tubes are about 4 inches (10 centimeters) long and about as wide as a piece of spaghetti. Within each tube is a tiny passageway no wider than a sewing needle. At the other end of each fallopian tube is a fringed area that looks like a funnel. This fringed area wraps around the ovary but doesn't completely attach to it. When an egg pops out of an ovary, it enters the fallopian tube. Once the egg is in the fallopian tube, tiny hairs in the tube's lining help push it down the narrow passageway toward the uterus.

When a baby girl is born, her ovaries contain hundreds of thousands of eggs, which remain inactive until puberty begins. At puberty, the pituitary gland, located in the central part of the brain, starts making hormones that stimulate the ovaries to produce female sex hormones, including estrogen. The secretion of these hormones causes a girl to develop into a sexually mature woman.

Toward the end of puberty, girls begin to release eggs as part of a monthly period called the menstrual cycle. Approximately once a month, during ovulation, an ovary sends a tiny egg into one of the fallopian tubes.

Unless the egg is fertilized by a sperm while in the fallopian tube, the egg dries up and leaves the body about 2 weeks later through the uterus. This process is called *menstruation* Blood and tissues from the inner lining of the uterus combine to form the menstrual flow, which in most girls lasts from 3 to 5 days. A girl's first period is called *menarche*

It's common for women and girls to experience some discomfort in the days leading to

their periods. Premenstrual syndrome **(PMS)** includes both physical and emotional symptoms that many girls and women get right before their periods, such as acne, bloating, fatigue, backaches, sore breasts, headaches, constipation, diarrhea, food cravings, depression, irritability, or difficulty concentrating or handling stress.

It can take up to 2 years from menarche for a girl's body to develop a regular menstrual cycle. During that time, her body is adjusting to the hormones puberty brings. On average, the monthly cycle for an adult woman is 28 days, but the range is from 23 to 35 days.

Fertilization

If a female and male have sex within several days of the female's ovulation (egg release), fertilization can occur. When the male ejaculates (which is when semen leaves a man's penis), between 0.05 and 0.2 fluid ounces (1.5 to 6.0 milliliters) of **semen** is deposited into the vagina. Between 75 and 900 million sperm are in this small amount of semen, and they "swim" up from the vagina through the cervix and uterus to meet the egg in the fallopian tube. It takes only one sperm to fertilize the egg.

About a week after the sperm fertilizes the egg, the fertilized egg (zygote) has become a multi-celled *blastocyst* Pregnancy lasts an average of 280 days — about 9 months.

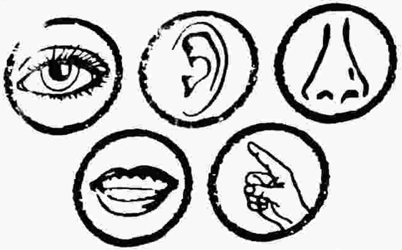
What is the difference between identical and fraternal twins?

Identical twins (also called monozygotic twins) occur when one fertilized egg splits and develops into two (or occasionally more) fetuses. The fetuses usually share one placenta. Identical twins have the same genes, so they generally look alike and are the same sex. A woman's chances of having identical twins are not related to age, race or family history.

Fraternal twins (also called dizygotic twins) develop when two separate eggs are fertilized by two different sperm. Each twin usually has its own placenta. Fraternal twins (like other siblings) share about 50 percent of their genes, so they can be different sexes. They generally do not look any more alike than brothers or sisters born from different pregnancies. Fraternal twins are more common than identical twins

Triplets and other higher-order multiples can result from three or more eggs being fertilized, one egg splitting twice (or more), or a combination of both. A set of higher-order multiples may contain all fraternal siblings or a combination of identical and fraternal siblings.

The Five Sense Organs in Human Beings



The sense organs — eyes, ears, tongue, skin, *and* nose — help to protect the body. The human sense organs contain receptors that relay information through sensoryneurons to the appropriate places within the nervous system. Each sense organ contains different receptors.

- **General receptors** are found throughout the body because they are present inskin, visceral organs (*visceral meaning in the abdominal cavity*), muscles, and joints.
- **Special receptors** *include* chemoreceptors (*chemical receptors*) found in the mouth and nose, photoreceptors (*light receptors*) found in the eyes, *andmechanoreceptors* found in the ears.

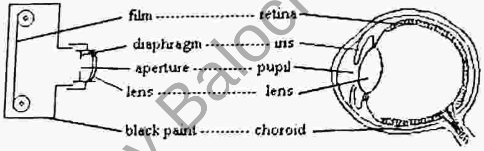
Aristotle classified five senses: hearing, sight, smell, taste, and touch, the last of which has a multiplicity of subdivisions, including the senses of pressure, heat, cold, contact, and pain. These have continued to be regarded as the classical five senses, although scientists have determined the existence of as many as 15 additional senses.

Sense organs buried deep in the tissues of muscles, tendons, and joints, for example, give rise to sensations of weight, position of the body, and amount of bending of the various joints; these organs are called proprioceptors. Within the semicircular canal of the ear is the organ of equilibrium, concerned with the sense of balance. General senses, which produce information concerning bodily needs (hunger, thirst, fatigue, and pain), are also recognized.

The Human Eye (CSS 1985, 1990, 2002)

The human eye is wrapped in three layers of tissue: the sclera, the choroid and the retina. The retina is the inner layer of the eye.

How Does The Human Eye Work?


film ---------- retina
diaphragm ---------- iris
aperture ---------- pupil
lens ---------- lens
black paint ---------- choroid

The individual components of the eye work in a manner similar to a camera. Each part plays a vital role in providing clear vision. So think of the eye as a camera with the cornea behaving much like a lens cover. As the eye's main focusing element, the cornea takes widely diverging rays of light and bends them through the pupil, the dark, round opening in the center of the colored iris. The iris and pupil act like the aperture of a camera.

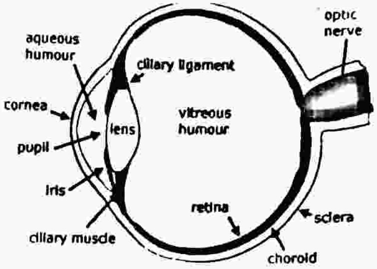
Next in line is the lens which acts like the lens in a camera, helping to focus light to the back of the eye. Note that the lens is the part which becomes cloudy and is removed during cataract surgery to be replaced by an artificial implant nowadays.

The very back of the eye is lined with a layer called the retina which acts very much like the film of the camera. The retina is a membrane containing photoreceptor nerve cells that lines the inside back wall of the eye. The photoreceptor nerve cells of the retina change the light rays into electrical impulses and send them through the optic nerve to the brain where an image is perceived. The center 10% of the retina is called the macula. This is responsible for your sharp vision, your reading vision. The peripheral retina is responsible for the peripheral vision. As with the camera, if the "film" is bad in the eye (i.e. the retina), no matter how good the rest of the eye is, you will not get a good picture.

Glossary of Eye Terms

Anterior Chamber

The cavity in the front part of the eye between the lens and cornea is called the Anterior Chamber. It is filled with Aqueous, a water-like fluid. This fluid is produced by the ciliary body and drains back into the blood circulation through channels in the chamber angle. It is turned over every100 minutes.



Chamber Angle

Located at the junction of the cornea, iris, and sclera, the anterior chamber angle extends 360 degrees at the perimeter of the iris. Channels here allow aqueous fluid to drain back into the blood circulation from the eye. May be obstructed in glaucoma.

Ciliary Body

A structure located behind the iris (rarely visible) which produces aqueous fluid that fills the front part of the eye and thus maintains the eye pressure. It also allows focusing of the lens.

Conjunctiva

A thin lining over the sclera, or white part of the eye. This also lines the inside of the eyelids. Cell in the conjunctiva produce mucous, which helps to lubricate the eye.

Cornea

The transparent, outer "window" and primary focusing element of the eye. The outer layer of the cornea is known as epithelium. Its main job is to protect the eye. The epithelium is made up of transparent cells that have the ability to regenerate quickly. The inner layer of the cornea is also made up of transparent tissue, which allows light to pass.

Hyaloid Canal

A narrow channel that runs from the optic disc to the back surface of the lens. It serves an embryologic function prior to birth but none afterwards.

Iris

Inside the anterior chamber is the iris. This is the part of the eye which is respons one's eye color. It acts like the diaphragm of a camera, dilating and constricting the pupil to more or less light into the eye.

Pupil

The dark opening in the center of the colored iris that controls how much light enters eye. The colored iris functions like the iris of a camera, opening and closing, to contr amount of light entering through the pupil.

Lens

The part of the eye immediately behind the iris that performs delicate focusing of li rays upon the retina. In persons under 40, the lens is soft and pliable, allowing for fine focus from a wide variety of distances. For individuals over 40, the lens begins to become less pliab making focusing upon objects near to the eye more difficult. This is known as presbyopia.

Macula

The part of the retina which is most sensitive, and is responsible for the central reading) vision. It is located near the optic nerve directly at the back of the eye (on the insid This area is also responsible for color vision.

Optic Disc

The position in the back of the eye where the nerve (along with an artery and vein) enters the eye corresponds to the "blind spot" since there are no rods or cones in thes location. Normally, a person does not notice this blind spot since rapid movements of the eye and processing in the brain compensate for this absent information. This is the area that the ophthalmologist studies when evaluating a patient for glaucoma, a condition where the optic nerve becomes damaged often due to high pressure within the eye. As it looks like a cup when viewed with an ophthalmoscope, it is sometimes referred to as the Optic Cup.

Optic Nerve

The optic nerve is the structure which takes the information from the retina as electric signals and delivers it to the brain where this information is interpreted as a visual image. The optic nerve consists of a bundle of about one million nerve fibers.

Retina

The membrane lining the back of the eye that contains photoreceptor cells. These photoreceptor nerve cells react to the presence and intensity of light by sending an impulse to the brain via the optic nerve. In the brain, the multitude of nerve impulses received from the photoreceptor cells in the retina are assimilated into an image.

Sclera

The white, tough wall of the eye. Few diseases affect this layer. It is covered by the episclera (a fibrous layer between the conjunctiva and sclera) and conjunctiva, and eye muscles are connected to this.

Vitreous

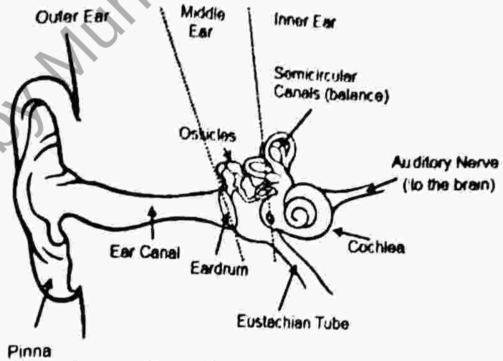
Next in our voyage through the eye is the vitreous. This is a jelly-like substance that fills the body of the eye. It is normally clear. In early life, it is firmly attached to the retina behind it. With age, the vitreous becomes more water-like and may detach from the retina. Often, little clumps or strands of the jelly form and cast shadows which are perceived as "floaters". While frequently benign, sometimes floaters can be a sign of a more serious condition such as a retinal tear or detachment and should be investigated with a thorough ophthalmologic examination.

The Human Ear

The ear is divided into three main parts - the outer ear, the middle ear, and the inner ear All three are involved in hearing but only the inner ear is responsible for balance.

The Outer (*external*) Ear

The outer ear consists of an outer, funnel-like structure called the auricle (or pinna) and an S-shaped tube, the external auditory meatus. The shapes of the outer ear (the auricle) and the external auditory canal can help amplify and direct the sound. The sound waves reverberate from the sides and end of the external auditory canal, filling it with the continuous vibrations of pressure waves.



An eustachian tube or auditory tube connects each middle ear to the throat. This tube allows air to pass between the tympanic cavity and the outside of the body by way of the throat and mouth. It is important in maintaining equal air pressure on both sides of the eardrum, which is necessary for normal hearing.

The Middle Ear

The middle ear consists of an air-filled space in the temporal bone called the tympanic cavity that separates the external and inner ears, an eardrum or tympanum (tympanic membrane), and three small bones called auditory ossicles. The tympanic membrane is the first structure to respond to sound by vibrating sympathetically with the airborne waves. The tympanic membrane is stretched across the end of the external auditory canal, and air molecules push against the membrane, causing it to vibrate at the same frequency as the sound wave. It has an oval margin and is cone-shaped, with the apex of the cone directed inward. Its cone shape is maintained by the attachment of one of the auditory ossicles (**malleus**).

The auditory ossicles being the smallest bones in the body are named according to their shape - the malleus (hammer), **incus** (anvil), and **stapes** (stirrup). The handle of the malleus is secured to the eardrum, and the base of the stapes fits into the oval window. Tiny ligaments suspend the ossicles, and minisynovial joints link them together in to a chain that spans the middle ear cavity. The ossicles transmit the vibratory motion of the eardrum to the oval window, which in turn sets the fluids of the inner ear into motion, eventually exciting the hearing receptors.

An eustachian tube (**auditory tube**) connects each middle ear to the throat. This tube allows air to pass between the tympanic cavity and the outside of the body by way of the nose and mouth. It is important in maintaining equal air pressure on both sides of the eardrum, which is important for normal hearing

The Inner Ear

The second step in hearing is the transmission of sound energy from the tympan membrane through the *middle-ear cavity* to the inner ear. The inner ear consists of a comp system of inter-communicating chambers and tubes called a labyrinth. There are two sep structures in each ear - the osseous and membranous labyrinths.

The parts of the labyrinths include a cochlea that functions in hearing, and three **semicircular canals** (anterior, posterior and lateral) that function in providing a sense of equilibrium. A bony chamber, called the vestibule, which is located between the cochlea and the semicircular canals, contains membranous structures (saccule and utricle) that serves both hearing and equilibrium.

The cochlea, as its name suggests, is shaped like the coiled shell of a snail. Inside, contains a bony core (modiolus) and a thin bony shelf (spiral lamina) that winds around the cor like threads of a screw. The compartments constitute the bony labyrinth of the cochlea, and the are filled with perilymph. It contains many thousands of stiff, elastic fibres, whose lengths var becoming progressively longer from the base of the cochlea to its apex. Vibrations entering the perilymph at the oval window travel along the scala vestibuli and pass through the vestibular membrane to enter the endolymph of the cochlear duct, where they cause movements in the basilar membrane.

The neurotransmitter simulates the mends of nearby sensory nerve fibres, and I respons they transmit nerve impulses along the cochlear branch of the vestibulo **cochlear nerve** to the brain. The brain then interprets these nerve impulses, and the hearing process is complete.

Mechanism of Hearing

When something makes a noise, it sends vibrations, or sound waves, through the air. The human eardrum is a stretched membrane, like the skin of a drum. When the sound waves hit your eardrum, it vibrates and the brain interprets these vibrations as sound.

After the vibrations hit your eardrum, a chain reaction is set off. Your eardrum, which is smaller and thinner than the nail on your pinky finger, sends the vibrations to the three smallest bones in your body. First the hammer, then the anvil, and finally, the stirrup. The stirrup passes those vibrations along a coiled tub in the inner ear called the cochlea.

Inside the cochlea there are thousands of hair-like nerve endings, cilia. When the Cochlea vibrates, the cilia move. Your brain is sent these messages (translated from vibrations by the cilia) through the auditory nerve.

Our brain then translates all that and tells us what we are hearing.

Human Teeth

People use their teeth to bite and chew food - they are the first step in the digestion of food. The long, sharp canine teeth tear up food (like meat). While we chew food, the tongue pushes the food to the teeth and saliva helps digestion and wets the food. Teeth also help us say certain sounds.

People have two sets of teeth in their lives, the primary teeth (also called the baby, milk or deciduous teeth) and the permanent teeth (also called the adult or secondary teeth). Children have 20 primary teeth; they are replaced by the permanent teeth by about age 13. Adults have 32 permanent teeth.

Teeth Types

Adult humans have a complete set of 32 permanent teeth,
of four different teeth types.
Sixteen permanent teeth at the top and sixteen at the bottom jaw:

- 8 incisors.
- 4 canines.
- 8 premolars,
- 12 molars.

- **Incisor** - a type of tooth with a narrow edge (in humans, the front teeth). Incisors are used to cut food. An incisor has 1 root. Adult humans have 8 incisors (4 in the top jaw and 4 in the bottom jaw).
- **Canine** (*also called cuspid*) - a type of tooth with a single point (also called canine tooth) and a single root. Cuspid teeth are used to hold and tear food. Adults have 4 canine teeth (2 in the top jaw and 2 in the bottom jaw). Canine means, "of or like a dog."
- **Premolar** (*also called bicuspid*) - the type of tooth located between the canine and the molars in humans. A bicuspid tooth has 1 root. Bicuspids have two points (cusps) at the top. Adults have 8 premolars (4 in the top jaw and 4 in the bottom jaw).
- **Molar** - a wide, flat tooth found in the back of mammal's mouths. Molars grind food during chewing. Molars in the top jaw have 3 roots; molars in the lower jaw have 2 roots. Adults have 12 molars (6 in the top jaw and 6 in the bottom jaw).
- **Wisdom teeth** (*also called the third molars*) are molars that usually erupt from the ages of 17 to 21.

Dental Formula

The number of each type of tooth varies from one species to another and the conventional way of describing them is by a "dental formula". The type of teeth are indicated by the first letter, and the number of teeth on one side of the upper jaw is indicated over the number of the same type of teeth on the lower jaw. Because the formula is for one side of the mouth the total number of teeth is the total in the formula x 2.

The dental formula where **I** = incisors, **C** = canines, **P** = premolars *and* **M** = molars:

Man *(adult)* **I** - 2/2 **C** - 1/1 **P** - 2/2 **M** - 3/3 = 16 x 2 = 32

Structure of Tooth

Tooth Enamel

Tooth Enamel is the hardest of the parts of the tooth and also the hardest of all the tissues of human body. Tooth enamel is a protective tooth structure that covers the exposed part of a tooth, the crown.

Dentin or Ivory

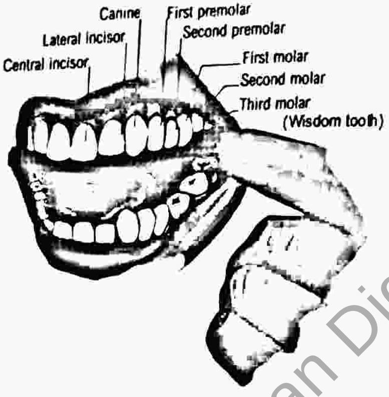
Dentin or Ivory is the tissue below the tooth enamel that forms the main mass of a ve It supports the tooth enamel and absorbs the pressure of eating. The dentine consists of a nume of micro-fibers imbedded in a dense homogeneous matrix of collagenous proteins.

Dental Pulp

Dental Pulp a soft connective tissue containing nerves and blood vessels that nourish th tooth. It is the most internal structure of a tooth, surrounded by the dentine. Dental pulp is loca in the soft center of the tooth, inside the pulp chamber and the root canal.

Cementum

Cementum is the part of tooth anatomy that covers the dentine outside of the root (unde the gum line) and it is attached to the bone of the jaw with little elastic fibers. Cementum is har as bone but not as hard as the tooth enamel.



Gums

Gums the tough pink-colored tissue that covers the bone of the jaw and supports the tooth structure inside the alveolar bone.

Periodontal Ligament

Periodontal Ligament the tissue between the Cementum and the alveolar bone. It consists of tough little elastic fibers that keep the tooth attached to the jaw.

Alveolar Bone

The bone of the jaw that keeps the tooth in its place, it feeds and protects it.

The internal tooth structure is common in all types of teeth, but the external teeth parts morphology (*shape of tooth crown, number and shape of roots*) differs significantly between different teeth types.

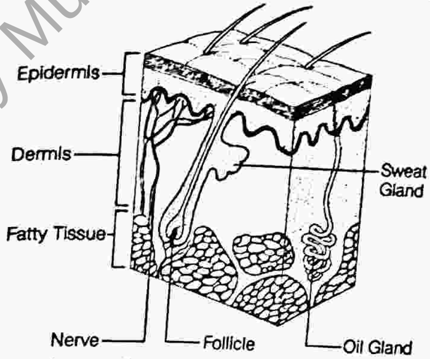
The Integumentary System

The *integumentary system* consists of the skin, hair, nails, the subcutaneous tissue below the skin, and assorted glands.

Human Skin

Our skin is largest organ. If the skin of a typical 150-pound (68-kilogram) adult male were stretched out flat, it would cover about 2 square yards (1.7 square meters) and weigh about 9 pounds (4 kilograms).

Skin protects the network of muscles, bones, nerves, blood vessels, and everything else inside our bodies. Eyelids have the thinnest skin, the soles of our feet the thickest.



Skin is essential to a person's survival.

- It forms a barrier that prevents harmful substances and microorganisms from entering the body.
- It protects body tissues against injury.
- Our skin also controls the loss of life-sustaining fluids like blood and water, helps us regulate body temperature through perspiration, and protects us from the sun's damaging ultraviolet rays.
- Without the nerve cells in our skin, we couldn't feel warmth, cold, or other sensations.

Every square inch of skin contains thousands of cells and hundreds of sweat glands, oil glands, nerve endings, and blood vessels. Skin is made up of three layers:

1. The epidermis
2. Dermis
3. Subcutaneous tissue.

The upper layer of our skin, the epidermis, is the tough, protective outer layer. It is about as thick as a sheet of paper over most parts of the body. The epidermis has four layers of cells that are constantly flaking off and being renewed. In these four layers are three special types of cells:

- **Melanocytes** produce **melanin**, the pigment that gives skin its color. All people have roughly the same number of melanocytes; those of dark-skinned people produce more melanin. Exposure to sunlight increases the production of melanin, which is why people get suntanned or freckled.

- **Keratinocytes** produce **keratin**, a type of protein that is a basic component of hair and nails. Keratin is also found in skin cells in the skin's outer layer, where it helps create a protective barrier.
- **Langerhans cells** help protect the body against infection.

Because the cells in the epidermis are completely replaced about every 28 days, cuts and scrapes heal quickly.

Below the epidermis is the next layer of our skin, the **dermis**, which is made up of blood vessels, nerve endings, and connective tissue. The dermis nourishes the epidermis.

Without certain molecules in the dermis, our skin wouldn't stretch when we bend or reposition itself when we straighten up. These two types of fibers in the dermis, **collagen** and **elastin**, help the skin stretch and reposition itself when we move.

The dermis also contains a person's sebaceous glands. These glands, which surround and empty into our hair follicles and pores, produce an oil called **sebum** (pronounced: **see-bum**) that lubricates the skin and hair. Sebaceous glands are found mostly in the skin on the face, upper back, shoulders, and chest.

The bottom layer of our skin, the **subcutaneous tissue**, is made up of connective tissue, sweat glands, blood vessels, and cells that store fat. This layer helps protect the body from blows and other injuries and helps it hold in body heat.

Hair and Nails

Hair

Hair is actually a modified type of skin. Hair grows everywhere on the human body except the palms of the hands, soles of the feet, eyelids, and lips. Hair grows more quickly in summer than winter, and more slowly at night than during the day.

Human hair consists of the hair shaft, which projects from the skin's surface, and the root, a soft thickened bulb at the base of the hair embedded in the skin. The root ends in the hair bulb, which sits in a sac-like pit in the skin called the follicle, from which the hair grows.

Each hair grows about ¼ inch (*about 6 millimeters*) every month and keeps on growing for up to 6 years. The hair then falls out and another grows in its place. The length of a person's hair depends on the length of the growing phase of the follicle. Follicles are active for 2 to 6 years; they rest for about 3 months after that. A person becomes bald if the scalp follicles become inactive and no longer produce new hair. Thick hair grows out of large follicles; narrow follicles produce thin hair.

Nails

Like hair, **nails** are a type of modified skin. Nails protect the sensitive tips of fingers and toes. Human nails aren't necessary for living, but they do provide support for the tips of the fingers and toes, protect them from injury, and aid in picking up small objects. Without them, we'd have a hard time scratching an itch or untying a knot. Nails can be an indicator of a person's general health, and illness often affects their growth.

The skin below the nail is called the matrix. The larger part of the nail, the nail plate, ooks pink because of the network of tiny blood vessels in the underlying dermis. The whitish rescent-shaped area at the base of the nail is called the **lunula**.

Smell and Taste

The Smell: Olfaction

Olfactory cells line the top of your nasal cavity. On one end, olfactory cells have cilia — hair-like attachments — that project into the nasal cavity. On the other end of the cell, are olfactory nerve fibers, which pass through the ethmoid bone and into the olfactory bulb. The olfactory bulb is directly attached to the cerebral cortex of our brain.

The olfactory cells are chemoreceptors, which means the olfactory cells have protein receptors that can detect subtle differences in chemicals.

As we breathe, anything that is in the air that we take in enters our nasal cavity: hydrogen, oxygen, nitrogen, dust, pollen, chemicals. We don't "smell" air or dust or pollen, but we can smell chemicals. The olfactory cells are chemoreceptors, which means the olfactory cells have protein receptors that can detect subtle differences in chemicals.

The chemicals bind to the cilia, which generate a nerve impulse that is carried through the olfactory cell, into the olfactory nerve fiber, up to the olfactory bulb and to our brain. Our brain determines what we are smelling. If we are sniffing something that we haven't experienced before, we need to use another sense, such as taste or sight, to make an imprint in our brain's memory.

Taste

Taste, one of the five special senses, which four gustatory qualities (sweetness, sourness, saltiness, and bitterness) of a substance are distinguished. Taste is determined by receptors, called taste buds, the number and shape of which may vary greatly between one person and another.

A greater number of taste buds appears to endow a greater sensitivity to sweetness, sourness, saltiness, and bitterness.

In humans, the taste buds are located on the surface and sides of the tongue, the roof of the mouth, and the entrance to the pharynx. The mucous membrane lining these areas is invested with tiny projections of papillae, each of which in turn is invested with 200 to 300 taste buds

The papillae located at the back of the tongue, and called circumvallate, are arranged to form a V with the angle pointing backward; they transmit the sensation of bitterness.Those at the tip of the tongue transmit sweetness, whereas saltiness and sourness are transmitted from the papillae on the sides of the tongue.

Human Health and Diseases

"Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

The correct bibliographic citation for the definition is:

Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948.

The Definition has not been amended since 1948.

Health is more than just being free from disease - it is a good physical feeling, a well-adjusted, positive individual who is able to undertake the tasks of their day without much difficulty. We also say "HEALTH IS WEALTH"

Disease can be defined as "An abnormal condition of an organism which interrupts the normal bodily functions that often leads to feeling of pain and weakness, and usually associated with symptoms and signs. A pathologic condition in which the normal functioning of an organism or body is impaired or disrupted resulting in extreme pain, dysfunction, distress, or death."

Medical Terminology used with Diseases

Acute	A disease, the symptoms of which are violent, and tend to a speedy termination, is called acute. Disease characterized by abrupt or sudden onset, usually with severe symptoms. Acute disease, as a rule, lasts a comparatively short time-no more than a few weeks.
Chronic	A disease whose progress is slow, in opposition to acute Disease characterized by longer duration, often months or years. It is usually associated with symptoms of less severe intensity
Communicable	Disease that is transmissible by direct or indirect contact with infection.
Complicating	Disease that occurs during or after an illness and has the same cause as the original disease or results from changes produced by the original disease
Congenital	Disease present in an infant at birth; it may be caused by hereditary factors or result from a prenatal condition or disease
Contagious	Highly transmissible disease
Endemic	Disease that occurs continuously or recurrently in a particular geographic region.
Epidemic	Disease that attacks simultaneously a large number of persons living in a particular geographic region.
Idiopathic	Disease in which the cause is unknown
Organic	Disease in which there are significant anatomical changes in the tissues or organs.
Pandemic	Disease that occurs more or less over the entire world at the same time.
Psychosomatic	Disease that seems to be caused or worsened by psychological factors. It may or may not produce anatomical changes
Secondary	Disease that results from a definite contributing factor. For instance, secondary anemia may result from blood loss or blood destruction.

Categories of Disease

There are *nine main categories of disease* but some diseases are more difficult to class and fit into more than one of them.

Physical disease

These diseases involve *temporary or permanent damage to the body* and include all the other categories except mental disease where there is no sign of physical damage to the brain. An example would be *leprosy*

Infectious disease *also called: Communicable diseases*

Infectious diseases kill more people worldwide than any other single cause. Infectious diseases are caused by germs. Germs are tiny living things that are found everywhere - in air, soil and water. *Pathogens* are organisms living in or on our bodies, causing disease. Infectious diseases are caused by pathogens such as *viruses, bacteria, fungi, protoctists, worms* and *insects,* which can be transmitted from person to person. This may be via normal social contact - for example, *chicken pox,* or via food and water, sexual contact or an animal bite.

Carriers are people who can transmit the pathogen but do not have the disease symptoms.

Diseases Caused by Viruses (CSS 1987/1994)

Viruses are very tiny organisms with their diameters in nanometers level. Viruses exist almost everywhere, such like in the air, soil and animal body. Human body also habors a lot of viruses, but most of them do not cause diseases. Human immune system can generate antibodies against viruses; the antibody will recognize the virus and destroy it. Sometimes the virus and human immune system can establish a balance. However when the human immune system is weak due to various reasons, the viruses can break the balance and cause problems, became so called opportunist pathogen.

List of diseases caused by viruses:

Influenza	Adenovirus Infections
Respiratory Syncytial Disease	Rhinovirus Infections
Herpes Simplex	Chicken pox (Varicella)
Measles (Rubeola)	German Measles (Rubella)
Mumps (Epidemic Parotitis)	Small Pox (Variola)
Warts Kawasaki Disease	Yellow Fever
Dengue Fever	Hepatitis A
Hepatitis B	NANB Hepatitis
Viral Gastroenteritis	Viral Fevers
Cytomegalovirus Disease	AIDS
Rabies	Polio
Slow Virus Disease	Arboviral Enephalitis

Virus has two types, DNA virus and RNA virus. The genome of DNA virus is consisted of DNA, and similarily RNA is the genetic material of a RNA virus.

Diseases Caused by Bacteria

Bacteria are infectious agents that attack the body and break down the immune system. They thrive as large groups of microorganisms that are unicellular in nature, spreading life-threatening diseases such as tuberculosis and the bubonic plague.

List of Diseases Caused by Bacteria

Disease	Transmission
Anthrax	Soil
Conjunctivitis	Contact
Botulism	Food, Water

Brucellosis	Food, Water
Clostridium perfringens	Food, Water
Diphtheria	Air
Endemic Typhus	Flea
Epidemic Typhus	Flea
Flavobacterium meningitis	Air
Gas Gangrene	Soil
Gonorrhea	Sexual
Haemophilus meningitis	Air
Klebsiella pneumonia	Air
Leprosy (Hansen's Disease)	Contact
Lymphogranuloma venereum	Sexual
Meningococcal meningitis	Air
Mycoplasma urethritis	Sexual
Pneumococcal pneumonia	Air
Primary atypical pneumonia	Air
Psittacosis	Air
Q fever	Air
Relapsing fever	Louse
Rickettsialpox	Mite
Rocky Mountain spotted fever	Tick
Salmonellosis	Food, Water
Scrub typhus	Mite
Serratia marcescens	Air
Shigellosis	Food, Water
Staphylococcal food poisoning	Food, Water
Staphylococcal infection	Contact
Syphilis	Sexual
Tetanus	Soil
Tick-borne diseases	Tick
Trachoma	Contact
Ureaplasma urethritis	Sexual
Vaginitis	Sexual

Diseases Caused by Fungi

Fungi are organisms that can grow in or on the body, causing infections of internal organs or of the skin, nails, and hair. Superficial fungal infections attack tissues on the surface of the body, which include the skin, nails, or hair. Some common examples are ringworm, athlete's foot, jock itch, and yeast infections. Candida yeast infections are usually found on the skin, in the mouth, in the vagina, on the head of the penis, or around the nails. Superficial fungal infections are somewhat contagious and pass from person to person through direct contact or, less commonly, through clothes or contact with surfaces of other objects in the environment

Protozoa are one of the three main classes of parasites that cause diseases in humans. They are single-celled organism, and can only be seen under a microscope. When they invade a human they are able to multiply easily, which causes them to be at a great advantage and puts humans at a disadvantage. This helps them survive in the human body and causes a serious

infection even with the arrival of a single protozoon.

Protozoan Diseases

1	Amoebiasis	2	Giardiasis
3	African sleeping sickness	4	Leishmaniasis
5	Toxoplasmosis	6	Malaria
7	Babesiosis	8	Trichomoniasis

Parasitic Worms

Over 25% of the world's population is infected by parasitic worms -- aka helminths. Although most parasitic worm infections are isolated to Third World countries, that number is large enough to cause anyone to shudder. Parasitic worms are invertebrate organisms with elongated, flat or round bodies that live inside their host, disrupting nutrient absorption -- in other words, they steal your food. Comparatively, only very few species of worms actually parasitize humans, but some of those that do can cause serious harm.

Parasitic worms are categorized into three groups:

1. Nematodes (roundworm, hookworm, whipworm)
2. Trematodes (schistosoma)
3. Cestodes (tapeworm)

Non-infectious diseases

These are all diseases, which are *not* caused by pathogens and *cannot* be passed on by physical contact. An example would be *sickle cell anaemia.*

Deficiency diseases

These are *nutritional* diseases caused by an inadequate or unbalanced diet. One or more essential nutrient is missing or in short supply - for example, a shortage of Vitamin C causes *scurvy.*

1 **Night-blindness:**

Cause:

This disease is caused due to the deficiency of vitamin A in the diet.

2 **Beri-beri:**

Cause:

This disease is caused due to the deficiency of vitamin-B.

3 **Scurvy:**

Cause:

This disease is caused due to the deficiency of vitamin-C.

4 **Rickets:**

Cause:

This disease is caused due to the deficiency of vitamin D.

5 **Anaemia:**

Cause:

This disease is caused due to the deficiency of iron.

6 **Goitre:**

Cause:

This disease is caused due to the deficiency of iodine.

Hereditary, and Genetic, Diseases (CSS 2010)

There are close to 4000 known hereditary, or genetic, diseases known to afflict humans - Some of these diseases are common, while others are quite rare and appear in what seem like isolated cases within a particular family. For the most part, genetic disorders are not curable, but through medicine and treatment, many of the symptoms are less burdensome for the afflicted. A hereditary disease is usually caused by a mutation to one of the genes in the person's makeup. In some cases, a gene might get deleted or have an abnormal length, causing a malfunction to occur. Though not all hereditary diseases necessarily have come from or manifest itself in a particular family, the mating of two people who might have a pre-disposition towards a certain disorder can create the perfect storm for their child to inherit the disorder as a result.Some hereditary disorders are quite common and are seen more often than others.

There are several different categories of genetic diseases that are divided by the type of gene or chromosome that transmits the disease. The most common are autosomal recessive, autosomal dominant, multifactorial, x-linked recessive and chromosomal abnormalities.

1	Sickle cell anemia	7	Tay-Sachs disease
2	Cystic fibrosis	8	Phenylketonuria
3	Huntington chorea	9	Cleft lip and palate
4	Spina bifida	10	Down syndrome
5	Color blindness	11	Hemophilia
6	Duchenne muscular dystrophy		

Hemophilia (CSS 1987, 1989, 1992)

Hemophilia is a rare bleeding disorder that prevents the blood from clotting properly, so a person who has it bleeds more than someone without hemophilia does. It's a genetic disorder, which means it's the result of a change in genes that was either inherited (passed on from parents to child) or occurred during development in the womb.

There are two major kinds of hemophilia, hemophilia A and hemophilia B. About 80% of cases are hemophilia A, which is a factor VIII deficiency. Hemophilia B is when factor IX is lacking.

Symptoms

- Prolonged nosebleeds
- Excessive bleeding from biting down on the lips or tongue
- Excessive bleeding following a tooth extraction or loss of a tooth
- Excessive bleeding following surgery
- Blood in the urine (called hematuria)

Inherited diseases

These diseases are caused by *genes* and can therefore be passed from parent to child. They are also sometimes called *genetic diseases* or *disorders.*

Degenerative diseases

These diseases are characterised by a *gradual loss of function*, in one or several organs or tissues. In old age, this is often the result of the failure of the bodies repair mechanisms - for example, loss of mobility due to worn joints.

However, degenerative diseases can strike in ones youth or middle age. They may be the result of poor nutrition in childhood or due to the immune system attacking the bodies, own cells

There are three main cotegories:

Diseases of skeletal, muscular and nervous tissues - for example, **osteoarthritis.**

Cardiovascular diseases of the circulatory system - for example, **coronary heart disease.**

Cancers.

Mental disorders

These disorders *affect a person's mind*, but may be accompanied by *physical symptoms.* Emotions, thoughts, memories and personal and social behaviour can be affected.

Some mental diseases are caused by degeneration of brain tissue - for example, *Alzheimer's* - a progressive deterioration in memory is followed by a general decline in all mental faculties (dementia). Other mental disorders seem to be accompanied by changes in the blood flow to the brain - for example, *Schizophrenia.*

Terms used to describe diseases

An *infectious* disease, which is always present in a *population*, is called *endemic.* An *epidemic* occurs when a disease suddenly *spreads rapidly* and *affects many people.* If a disease spreads over a continent or even the world it will be termed *pandemic.*

Communicable Disease

Communicable diseases refer to diseases that can be transmitted and make people ill. They are caused by infective agents (pathogens) e.g. bacteria and viruses, which invade the body and multiply or release toxins to cause damages to normal body cells and their functions. In severe cases, they may lead to death. These infective agents can spread from a source of infection (e.g. patients, sick animals) to a person through various routes of transmission.

Source of infection

This refers to any environment, in which infective agents can live, parasitize and breed. It includes humans (e.g. patients, carriers and people with latent infections), livestock, insects and soil. The source of infection will normally form the basis for infective agents to infect humans.

Communicable Disease Transmission

Mode *of* Transmission	Process	Examples *of* Communicable Diseases
Contact transmission		
Direct Contact	Through direct body contact with the infected, e.g. lifting and assisting in taking baths	Scabies, Chickenpox, Head lice, Acute conjunctivitis
Indirect Contact	Through contact with objects contaminated by infective agents, e.g. sharing towels, combs and clothes	
Droplet Transmission	Through droplets expelled during sneezing, coughing, spitting and speaking, or subsequent touching of mucous membranes of the mouth, nose and eyes etc with hands contaminated with infective agents	SARS, Influenza
Airborne Transmission	The infective agents float in the air for sometime and then enter the body through the respiratory tract	Chickenpox, Pulmonary tuberculosis (*smear positive*)
Common Vectors (*e.g.* food-borne, water-borne)	Infective agents enter the body through ingestion of contaminated food or water, or contact with contaminated devices like eating utensils, urinary catheters	Food poisoning, Cholera, Bacillary dysentery, Hepatitis A, Urinary tract infection
Vectors (*insects*)	The infective agents either parasitize	Dengue fever, Malaria

	and breed in the body of the insects, or contaminate the legs and mouths of the insects and then infect human when the insects bite humans or by crosscontamination	(mosquitoborne), Infections, gastrointestinal diseases (*fly-borne or rodent-borne*)
Blood/Body fluid Transmission	Transmitted through blood transfusion, tattooing, ear piercing or sexual intercourse	Hepatitis B, AIDS
Congenital Infection	Infective agents enter the foetus through the mother causing infection	Congenital syphilis

Immune System (CSS 1987, 1995)

An Overview of the Body's Defences

Non-Specific Defense Mechanisms		Specific Defense Mechanisms
First Line of Defense	**Second Line of Defense**	**Third Line of Defense**
Skin Mucous Membranes	Phagocytic white blood cells Antimicrobial proteins Inflammatory response	The Immune System Lymphocytes Antibodies

We are surrounded by millions of bacteria, viruses and other microbes (*germs*) that have the potential to enter our bodies and cause harm. The immune system is the body's defence against pathogens (*disease-causing microbes*). The immune system is made up of non-specialised defences such as skin and the acidic juice produced by your stomach. But it also has some highly specialised defences which give you immunity against (*resistance to*) particular pathogens. These defences are special white blood cells called lymphocytes. Other types of white blood cells play an important part in defending your body against infection.

The cells that are part of this defense system are white blood cells or leukocytes. They come in two basic types which combine to seek out and destroy the organisms or substances that cause disease. Leukocytes are produced or stored in many locations throughout the body, including the thymus, spleen, and bone marrow. For this reason, they are called the **lymphoid** organs. There are also clumps of lymphoid tissue throughout the body, primarily in the form of lymph nodes that house the leukocytes.

There are two basic types of leukocytes:

1. The **phagocytes** are cells that chew up invading organisms.
2. The **lymphocytes** are cells that allow the body to remember and recognize previous invaders and help the body destroy them.

A number of different cells are considered phagocytes. The most common type is the **neutrophil** which primarily fights bacteria. So when doctors are worried about a bacterial infection, sometimes they order a blood test to see if a patient has an increased number of neutrophils triggered by the infection. Other types of phagocytes have their own jobs to make sure that the body responds appropriately to a specific type of invader.

There are two kinds of lymphocytes: the **B lymphocytes** and the **T lymphocytes**

Lymphocytes start out in the bone marrow and either stay and mature there to become B cells or leave for the thymus gland, where they mature to become T cells.

B lymphocytes and T lymphocytes have separate jobs to do:

- **B lymphocytes** are like the body's military intelligence system, seeking out their targets and sending defenses to lock onto them.
- **T cells** are like the soldiers, destroying the invaders that the intelligence system has identified.

A foreign substance that invades the body is called an **antigen** (pronounced: **an**-tih-jun). When an antigen is detected, several types of cells work together to recognize and respond to it. These cells trigger the B lymphocytes to produce **antibodies** (pronounced: **an**-tye-bah-deez). Antibodies are specialized proteins that lock onto specific antigens. Antibodies and antigens fit together like a key and a lock.

Once the B lymphocytes recognize specific antigens, they develop a memory for the antigen and will immediately produce antibodies the next time the antigen enters a person's body. That's why if someone gets sick with a certain disease, like chickenpox, that person typically doesn't get sick from it again.

This is also why we use immunizations to prevent certain diseases. The immunization introduces the body to the antigen in a way that doesn't make a person sick, but it does allow the body to produce antibodies that will then protect that person from future attack by the germ or substance that produces that particular disease.

Although antibodies can recognize an antigen and lock onto it, they are not capable of destroying it without help. That is the job of the T cells. The T cells are part of the system that destroys antigens that have been tagged by antibodies or cells that have been infected or somehow changed. (There are actually T cells that are called "killer cells.") T cells are also involved in helping signal other cells (like phagocytes) to do their jobs.

Immunity

Humans have three types of immunity — innate, adaptive, and passive:

Innate Immunity

Everyone is born with innate (or natural) immunity, a type of general protection that humans have. Many of the germs that affect other species don't harm us. For example, the viruses that cause leukemia in cats or distemper in dogs don't affect humans. Innate immunity works both ways because some viruses that make humans ill — such as the virus that causes HIV/AID

Adaptive Immunity

We also have a second kind of protection called adaptive (or active) immunity. This type of immunity develops throughout our lives. Adaptive immunity involves the lymphocytes (as in the process described above) and develops as children and adults are exposed to diseases or immunized against diseases through vaccination.

Passive Immunity

Passive immunity is "borrowed" from another source and it lasts for a short time. For example, antibodies in a mother's breast milk provide an infant with temporary immunity to diseases that the mother has been exposed to. This can help protect the infant against infection during the early years of childhood.

Everyone's immune system is different. Some people never seem to get infections, whereas others seem to be sick all the time. As people get older, they usually become immune to more germs as the immune system comes into contact with more and more of them. That's why adults and teens tend to get fewer colds than kids — their bodies have learned to recognize an immediately attack many of the viruses that cause colds.

Immunization *or* Vaccination

Immunization, also called vaccination or inoculation, a method of stimulating resistance in the human body to specific diseases using microorganisms—bacteria or viruses—that have been modified or killed. These treated microorganisms do not cause the disease, but rather trigger the body's immune system to build a defense mechanism that continuously guards against the disease. If a person immunized against a particular disease later comes into contact with the disease-causing agent, the immune system is immediately able to respond defensively.

History of Vaccination

A significant breakthrough came in 1796 when British physician Edward Jenner discovered that he could immunize patients against smallpox by inoculating them with material from cowpox sores. Cowpox is a far milder disease that, unlike smallpox, carries little risk of death or disfigurement. Jenner inserted matter from cowpox sores into cuts he made on the arm of a healthy eight-year-old boy. The boy caught cowpox. However, when Jenner exposed the boy to smallpox eight weeks later, the child did not contract the disease. The vaccination with cowpox had made him immune to the smallpox virus. Today we know that the cowpox virus antigens are so similar to those of the smallpox virus that they trigger the body's defenses against both diseases.

- In 1885, Louis Pasteur created the first successful vaccine against rabies for a young boy who had been bitten 14 times by a rabid dog. Over the course often days, Pasteur injected progressively more virulent rabies organisms into the boy, causing the boy to develop immunity in time to avert death from this disease.
- 1933 French researchers develop a neurotropic vaccine against yellow fever using a strain of attenuated yellow fever virus
- In 1954 Jonas Salk introduced an injectable vaccine containing an inactivated virus to counter the epidemic of poliomyelitis.
- Subsequently, Albert Sabin made great strides in the fight against this paralyzing disease by developing an oral vaccine containing a live weakened virus. Since the introduction of the polio vaccine, the disease has been nearly eliminated in many parts of the world.

Vaccine

A vaccine is any preparation intended to produce immunity to a disease by stimulating the production of antibodies. Vaccines include, for example, suspensions of killed or attenuated microorganisms, or products or derivatives of microorganisms. The most common method of administering vaccines is by injection, but some are given by mouth or nasal spray.

Vaccines work by stimulating our immune system to produce antibodies (substances produced by the body to fight disease) without actually infecting us with the disease.

Vaccines trigger the immune system to produce its own antibodies against disease, as though the body has been infected with it. This is called "active immunity". If the vaccinated person then comes into contact with the disease itself, their immune system will recognise it and immediately produce the antibodies they need to fight it.

Delivery systems

There are several new delivery systems in development in the hope of making vaccines more efficient to deliver.

The latest developments in vaccine delivery technologies have resulted in oral vaccines

A polio vaccine was developed and tested by volunteer vaccinations with no formal training; the results were positive in that the ease of the vaccines increased. With an oral vaccine, there is no risk of blood contamination.

Vaccine development has several trends

- Until recently most vaccines were aimed at infants and children, but adolescents and adults are increasingly being targeted.
- Combinations of vaccines are becoming more common; vaccines containing five or more components are used in many parts of the world in 2013, Biofarma has released new product called Pentabio which is combination vaccine of Diptheria, Tetanus, Pertussis, Hepatitis B and Haemophilus Influenzae Type B for baby/infant of Indonesia Immunization Program.
- New methods of administering vaccines are being developed such as skin patches, aerosols via inhalation devices, and eating genetically engineered plants.
- Vaccines are being designed to stimulate innate immune responses, as well as adaptive.
- Attempts are being made to develop vaccines to help cure chronic infections, as opposed to preventing disease.
- Vaccines are being developed to defend against bioterrorist attacks such as anthrax, plague, and smallpox.
- Scientists are now trying to develop synthetic vaccines by reconstructing the outside structure of a virus.

Types of Vaccines

Live, attenuated

Live attenuated vaccines should not be given to individuals with weakened or damaged immune systems. To maintain potency, live attenuated vaccines require refrigeration and protection from light.

Examples include Measles, Mumps Rubella (MMR) and Influenza Vaccine Live, Intranasal (FluMist)

Inactivated

An inactivated vaccine cannot cause disease and is generally safe for those with weakened or damaged immune systems.

*Examples include **influenza** inactivated vaccine (injectable)*

Subunit

Since only the specific, necessary parts of the germ are used for this type of vaccine, the adverse events risk is lower.

*Examples include the **Hepatitis B** vaccine.*

Conjugate

Similar to subunit vaccines, conjugate vaccines use only portions of the germ.

Examples include Haemophilus Influenza Conjugate Vaccine (Hib) and Pneumoccocal Conjugate Vaccine (Prevnar)

Toxoid

The **toxins secreted by bacteria are inactivated** to make toxoid vaccines. This technique is reserved for diseases in which the secreted toxins are the main cause of the illness.

Examples include tetanus and diphtheria vaccines.

DNA vaccines

This type of vaccine would hopefully produce better protection like a live virus vaccine but with even less likelihood of producing disease; it would not contain the actual disease causing part of the germ and therefore cannot cause the disease. There are currently studies of DNA vaccines for herpes and influenza.

Recombinant vector vaccines

These vaccines are similar to DNA vaccines except the weakened or attenuated germ is used to carry DNA to the cells to stimulate immunity. Currently, scientists are working on HIV, rabies and measles vaccines using this technology.

Vaccine Immunity

Vaccines have contributed to the eradication of smallpox, one of the most contagious and deadly diseases known to man. Other diseases such as rubellam polio, measles, mumps, chickenpox, and typhoid are nowhere near as common as they were a hundred years ago. As long as the vast majority of people are vaccinated, it is much more difficult for an outbreak of disease to occur, let alone spread. This effect is called herd immunity. Polio, which is transmitted only between humans, is targeted by an extensive eradication campaign that has seen endemic polio restricted to only parts of four countries (*Afghanistan, India, Nigeria and Pakistan*). The difficulty of reaching all children as well as cultural misunderstandings, however, have caused the anticipated eradication date to be missed several times.

Vaccine Effectiveness

Vaccines do not guarantee complete protection from a disease. Sometimes, this is because the host's immune system simply does not respond adequately or at all. This may be due to a lowered immunity in general (diabetes, steroid use, HIV infection, age) or because the host's immune system does not have a B cell capable of generating antibodies to that antigen.

Even if the host develops antibodies, the human immune system is not perfect and in any case the immune system might still not be able to defeat the infection immediately. In this case, the infection will be less severe and heal faster.

The efficacy or performance of the vaccine is dependent on a number of factors:

- The disease itself (for some diseases vaccination performs better than for other diseases)
- The strain of vaccine (some vaccinations are for different strains of the disease)
- Whether one kept to the timetable for the vaccinations some individuals are "non-responders" to certain vaccines, meaning that they do not generate antibodies even after being vaccinated correctly
- Other factors such as ethnicity, age, or genetic predisposition.

Some Diseases and their Vaccines

Diseases or conditions	Vaccine(s)
Hepatitis A	Hepatitis A vaccine
Hepatitis B	Hepatitis B vaccine
Hepatitis E	Hepatitis E vaccine
Influenza	Influenza vaccine
Measles	MMR vaccine, MMRV vaccine
Poliomyelitis	Polio vaccine
Chickenpox, Shingles	Varicella vaccine, Shingles vaccine,
Smallpox	Smallpox vaccine
Yellow fever	Yellow Fever vaccine
Anthrax	Anthrax vaccines
Tetanus	DPT vaccine
Diphtheria	DPT vaccine
Q fever	Q fever vaccine
Typhoid fever	Typhoid vaccine
Cholera	Cholera vaccine

Antibiotics

Antibiotics, also known as antibacterial, are types of medications that destroy or slow down the growth of bacteria. The Greek word *anti* means "against", and the Greek word *bios* means "life" (*bacteria are life forms*).

Antibiotics do not fight infections caused by viruses, such as

- Colds
- Flu
- Most coughs and bronchitis
- Sore throats, unless caused by strep

Antibiotics are used to treat infections caused by bacteria. Bacteria are microscopic organisms, some of which may cause illness. The word bacteria is the plural of bacterium.

The first antibiotic was penicillin. Such penicillin-related antibiotics as ampicillin, amoxicillin and benzylpenicilllin are widely used today to treat a variety of infections - these antibiotics have been around for a long time. There are several different types of modern antibiotics and they are only available with a doctor's prescription in industrialized countries.

How do antibiotics work?

Although there are a number of different types of antibiotic they all work in one of two ways:

- A bactericidal antibiotic kills the bacteria. Penicillin is a bactericidal. A bactericidal usually either interferes with the formation of the bacterium's cell wall or its cell contents.
- A bacteriostatic stops bacteria from multiplying.

An antibiotic is a **selective poison**. It has been chosen so that it will kill the desired bacteria, but not the cells in your body. Each different type of antibiotic affects different bacteria in different ways. For example, an antibiotic might inhibit a bacterium's ability to turn glucose into energy, or its ability to construct its cell wall. When this happens, the bacterium dies instead of reproducing. At the same time, the antibiotic acts only on the bacterium's cell-wall-building mechanism, not on a normal cell's

Antibiotics *do not* Work *on* Viruses

Antibiotics do not work on viruses because viruses are not alive. A bacterium is a living, reproducing lifeform. A virus is just a piece of DNA (or RNA). A virus injects its DNA into a living cell and has that cell reproduce more of the viral DNA. With a virus there is nothing to "kill," so antibiotics don't work on it.

An antibiotic is given for the treatment of an infection caused by bacteria. Antibiotics target microorganisms such as bacteria, fungi and parasites. However, they are not effective against viruses. If you have an infection it is important to know whether it is caused by bacteria or a virus. Most upper respiratory tract infections, such as the common cold and sore throats are generally caused by viruses - antibiotics do not work against these viruses

Side-effects of Antibiotics

The most common side effects of antibiotics affect the digestive system. These occur in around 1 in 10 people.

Side effects of antibiotics that affect the digestive system include:

- being sick
- feeling sick
- diarrhoea
- bloating and indigestion
- abdominal pain
- loss of appetite

These side effects are usually mild and should pass once you finish your course of treatment.

Antibiotic allergic reactions

Around 1 person in 15 has an allergic reaction to antibiotics, especially penicillin and cephalosporins. In most cases the allergic reaction is mild to moderate and can take the form of:

- a raised itchy skin rash (urticaria or 'hives')
- coughing
- wheezing
- tightness of the throat, which can cause breathing difficulties

These mild to moderate allergic reactions can usually be successfully treated by taking a medication known asantihistamines.

Types of antibiotics

There are now hundreds of different types of antibiotics but most of them can be broadly classified into six groups.

1) **Penicillin:** Penicillin is widely used to treat certain infections such as skin infections, chest infections and urinary tract infections.
2) **Cephalosporins:** Cephalosporins are broad-spectrum antibiotics, which means they are effective in treating a wide range of different types of infections including more serious infections
3) **Aminoglycosides:** Aminoglycosides are a type of antibiotic that used to be widely prescribed until it was found that they could cause both damage to hearing and the kidneys. Because of this, they tend now to be used only to treat very serious illnesses such as meningitis.
4) **Tetracyclines:** Tetracyclines are another type of broad-spectrum antibiotic that can be used to treat a wide range of infections.They are commonly used to treat severe acne and a condition called rosacea, which causes flushing of the skin and spots.
5) **Macrolides:** Macrolides are a type of antibiotic that can be particularly useful in treating lung and chest infections.
6) **Fluoroquinolones:** Fluoroquinolones are the newest type of antibiotic. They are broad-spectrum antibiotics that can be used to treat a wide range of infections.

Classifications

Although there are several classification schemes for antibiotics, based on bacterial spectrum (*broad versus narrow*) or route of administration (*injectable versus oral versus topical*), or type of activity (*bactericidal vs. bacteriostatic*), the most useful is based on chemical structur. Antibiotics within a structural class will generally show similar patterns of effectiveness, toxicity and allergic potential.

Difference between Antibiotics and Vaccines

Vaccine	Antibiotic
Vaccine kills virus	Antibiotics kill bacteria
Vaccine is taken once and has permanent effect	Antibiotics work during the time of disease.
Vaccines can be given orally or through injection.	Antibiotics are available in different forms like tablets, capsules, drops or ointments
Vaccines are preventive method that is taken before getting infected.	Antibiotics are taken after getting infected.

Difference between Antibodies and Antibiotics (CSS 2011)

Antibodies are special chemicals produced by the body to fight the disease-causing microbes that enter the body.

Antibiotics are chemicals produced by microorganisms which are capable of destroying or inhibiting the growth of other microorganism. The microorganism that produce antibiotics are mostly bacteria but some fungi also produce it.

Antibodies	Antibiotics
Antibodies are produced by the body against any disease causing microbe	Antibiotics are chemicals produced by microorganisms to inhibit the growth of other microorganisms.
Antibodies are produced within the body of infected person	Antibiotics are external chemicals that kill germs
These are produced by WBCs in our body.	These are produced by using bacteria and fungi.
They are specific to the antigen (microbe)	A single antibiotic can be used to kill more than one microbe.
Examples; IgG, IgA etc	Example; penicillin, ampicillin

Viruses (CSS 1987, 1994)

Viruses are tiny organisms that may lead to mild to severe illnesses in humans, animals and plants. This may include flu or a cold to something more life threatening like HIV/AIDS. The virus particles are 100 times smaller than a single bacteria cell. The bacterial cell alone is more than 10 times smaller than a human cell and a human cell is 10 times smaller than the diameter of a single human hair.

Article I. Structure of a virus

A virion (*virus particle*) has three main parts:

Nucleic acid – this is the core of the virus with the DNA or RNA (deoxyribonucleic acid and ribonucleic acid respectively). The DNA or RNA holds all of the information for the virus and that makes it unique and helps it multiply.

Protein Coat (*capsid*) – This is covering over the nucleic acid that protects it.

Lipid membrane (*envelope*) – this covers the capsid. Many viruses do not have this envelope and are called naked viruses.

How do viruses infect?

Viruses do not have the chemical machinery needed to survive on their own. They, thus seek out host cells in which they can multiply. These viruses enter the body from the environment or other individuals from soil to water to air via nose, mouth, or any breaks in the skin and seek a ell to infect.

A cold or flu virus for example will target cells that line the respiratory (*i.e.* the lungs) or gestive (i.e. the stomach) tracts. The HIV (human immunodeficiency virus) that causes AIDS attacks the T-cells (a type of white blood cell that fights infection and disease) of the immune system.

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Some human diseases caused by viruses

	Burkitt's lymphoma
AIDS	Colds
Chicken pox	Dengue
Colorado tick fever	Fever blisters
Encephalitis	Gastroenteritis
Genital warts	German measles
Genital herpes	Influenza
Hepatitis	Liver cancer
Leukemia	Mononucleosis
Measles	Oral herpes
Mumps	Rabies
Polio	Smallpox
Shingles	Warts
Virus hemorrhagic fever	
Yellow fever.	

Meningitis (CSS 2000)

Meningitis is an inflammation of the membranes (meninges) surrounding your brain and spinal cord.

Meningitis is inflammation of the coverings around the brain and spinal cord. It is usually caused by an infection.

The infection occurs most often in children, teens, and young adults. Also at risk are older adults and people who have long-term health problems, such as a weakened immune system.

There are two main kinds of meningitis:

- Viral meningitis is fairly common. It usually does not cause serious illness. In severe cases, it can cause prolonged fever and seizures.
- Bacterial meningitis is not as common but is very serious. It needs to be treated right away to prevent brain damage and death.

Causes

Viral meningitis is caused by viruses. Bacterial meningitis is caused by bacteria. Meningitis can also be caused by other organisms and some medicines, but this is rare. Meningitis is contagious. The germs that cause it can be passed from one person to another through coughing and sneezing and through close contact.

Lumbar puncture is the most important lab test for meningitis. It is also called a spinal tap. A sample of fluid is removed from the spine and tested to see if it contains organisms that cause the illness.

Pollen Allergy (CSS 2006)

Pollens are tiny egg-shaped powdery grains released from flowering plants, which are carried by the wind or insects, and serve to cross-pollinate other plants of the same type for reproductive purposes. When pollen is present in the air, it can land in a person's eyes, nose, lungs, and on their skin to set up an allergic reaction.

Symptoms may include allergic rhinitis (hay fever), allergic conjunctivitis (eye allergies) and allergic asthma.

Causes

Pollens that are spread by the wind are usually the main cause of seasonal allergies, while pollens that rely on insects (such as the honeybee) to be carried to other plants do not. Most plants with bright, vibrant flowers (such as roses) are insect pollinated and do not generally cause seasonal allergies since the pollen is not usually present in the air.

When pollen grains get into the nose of someone who's allergic, they send the immune system into overdrive. "When pollen enters our body, the immune system, mistakenly sees the pollen as foreign invaders, releases antibodies or substances that normally identify and attack bacteria, viruses, and other illness-causing organisms." The antibodies attack the allergens, which leads to the release of chemicals called histamines into the blood Histamines trigger sneezing, a runny nose and itchy eyes.

In Pakistan the bhang pollen count causes allergies from July to September, according to researchers.

Bird Flu (CSS 2006)

The H5N1 strain of influenza - often referred to as bird flu - is first known to have jumped from chickens to humans in 1997. Since 2004 it has ripped through poultry and wild bird populations across Eurasia

Avian flu, also known as bird flu and more formally as avian influenza, refers to flu caused by viruses that infect birds and make them ill. It is an infectious disease of birds caused by type A strains of the influenza virus. HPAI (*highly pathogenic avian influenza*) - the more virulent one - is the one health care authorities are most concerned about. Avian flu affects several types of birds, including farmed poultry, i.e. chickens, geese, turkeys and ducks. *Avian flu is the illness caused by the Avian influenza virus.*

Bird flu can be transmitted from livestock to wild birds and also to pet birds, and vice-versa. The virus spreads through infected birds, via their saliva, nasal secretions, feces, and feed.

Types of Avian Flu/Bird Flu

There are 16 different avian flu types. The H5N1 strain is the one that causes the most concern, because it is the most virulent; the deadliest. Fortunately, humans do not become easily infected with the H5N1 virus strain. However, some highly pathogenic strains have caused severe respiratory diseases in humans. In the vast majority of cases of human infections, there was contact with infected poultry or objects/surfaces contaminated with their feces or secretions.

Causes of Avian Flu

Humans can become infected and ill with avian influenza after coming into contact with infected birds. A human infection was first identified in China in March 30th, 2013. By April 18th, 2013 confirmed cases of human infection had been reported in Shanghai, Anhui, Jiangsu, Zhejiang, Beijing, and Henan. The following circumstances have been linked to human illness:

- Touching infected birds
- De-feathering infected birds
- Touching secretions from infected birds (saliva or fluids from infected birds)
- Being in contact with the feces of infected birds
- Inhaling dried feces dust from infected birds
- Preparing poultry for cooking, if the bird was infected. This also includes household settings
- Slaughtering or butchering infected poultry
- Markets where live birds are sold. If the birds are infected, those who handle them have a

risk of becoming ill

Signs and symptoms of Avian Flu

Humans with avian flu may have the following signs and symptoms (*many are the same as normal seasonal human flu*):

A cough, usually dry	A high fever, over 38C
Aching bones, joints and muscles	Bleeding from the nose
Blocked nose	Chest pain
Cold sweats and chills	Fatigue
Headache	Loss of appetite
Runny nose	Sleeping difficulties
Stomach upset, sometimes diarrhea	Bleeding from the gums
Hoarse voice	Sputum is sometimes bloody

Some patients develop the symptoms of lower respiratory tract infection, which include breathing difficulties. This occurs around day five of the first symptoms

Patients with avian influenza can deteriorate rapidly, resulting in pneumonia, multiple organ failure, and death.

Short-sightedness (Myopia) (CSS 1998)

Short-sightedness is a very common eye condition that causes distant objects to appear blurred, while close objects can be seen clearly. Myopia is the medical term for short-sightedness.

Cases of short-sightedness can range from mild, where treatment may not be required, to very severe, which can significantly affect vision.

The symptoms of short-sightedness often start around puberty and get gradually worse until the eye is fully grown. Therefore it's important to have regular eye examinations. If you notice that distant objects seem to be fuzzy or your child is struggling to see things in the distance, such as the blackboard at school, you should arrange for a sight test with an optometrist (*optician*).

Causes Short-Sightedness?

Short-sightedness is a refractive eye condition. Refractive eye conditions are caused when problems with the structure of the eye affects how light rays enter your eye.

Most people are born slightly long-sighted (where close objects appear blurred) because their eyes haven't grown to their full length. The eye then grows to their normal length, which should lead to the resumption of normal vision.

Generally, short-sightedness happens when the eye continues to grow and becomes too long from front to back As a result; light rays don't reach the retina at the back of the eye. They only focus in front of it. This means that objects in the distance seem blurred.

Most cases of short-sightedness are caused by a combination of genetic and environmental factors that disrupt the normal growth of the eye.

- Short-sightedness is a refractive eye condition. Refractive eye conditions are caused when problems with the structure of the eye affects how light rays enter your eye.
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- Most cases of short-sightedness are caused by a combination of genetic and environmental factors that disrupt the normal growth of the eye.
- Short-sightedness is thought to be slightly more common in females than in males.

Treating short-sightedness

There are three main treatment options for short-sightedness. They are:

- **using corrective lenses,** such as glasses or contact lenses, to compensate for the defect in the cornea
- **using laser surgery** – to correct the defect (laser surgery can't be used in children because their eyes are still developing); most people will have to pay to have private laser surgery
- **implanting an artificial lens** into the eye to compensate for the longer eye length

Dengue Fever (CSS 2009)

Dengue fever is a painful, debilitating mosquito-borne disease caused by any one of four closely related dengue viruses. These viruses are related to the viruses that cause West Nile infection and yellow fever.

Dengue fever is transmitted by the bite of an Aedes mosquito infected with a dengue virus. The mosquito becomes infected when it bites a person with dengue virus in their blood. It can't be spread directly from one person to another perso

How is dengue fever contracted?

The virus is contracted from the bite of a striped *Aedes aegypti* mosquito that has previously bitten an infected person. The mosquito flourishes during rainy seasons but can breed in water-filled flower pots, plastic bags, and cans year-round. One mosquito bite can cause the disease.

The virus is not contagious and cannot be spread directly from person to person. There must be a person-to-mosquito-to-another-person pathway.

Symptoms of Dengue Fever

Symptoms, which usually begin four to six days after infection and last for up to 10 days, may include

- Sudden, high fever
- Severe headaches
- Pain behind the eyes
- Severe joint and muscle pain
- Nausea
- Vomiting
- Skin rash, which appears three to four days after the onset of fever
- Mild bleeding (such a nose bleed, bleeding gums, or easy bruising)

Because dengue fever is caused by a virus, there is no specific medicine or antibiotic to treat it. For typical dengue, the treatment is purely concerned with relief of the symptoms. Rest and fluid intake for adequate hydration is important. Aspirin and nonsteroidal anti-inflammatory drugs should only be taken under a doctor's supervision because of the possibility of worsening bleeding complications. Acetaminophen (*Tylenol*) and codeine may be given for severe headache and for joint and muscle pain (*myalgia*).

Swine Flu

(*H1N1 and H3N2v influenza virus*) (CSS 2010)

Swine flu is a respiratory disease caused by influenza viruses that infect the respiratory tract of pigs and result in a barking cough, decreased appetite, nasal secretions, and listless behavior. Swine flu viruses may mutate (change) so that they are easily transmissible among humans. The 2009 swine flu outbreak was due to infection with the so-called H1N1 virus and was first observed in Mexico.

Symptoms of swine flu in humans are similar to most influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache. Two antiviral agents, zanamivir (Relenza) and oseltamivir (Tamiflu), have been reported to help prevent or reduce the effects of swine flu if taken within 48 hours of the onset of symptoms

Causes of Swine Flu

The cause of the 2009 swine flu was an influenza A virus type designated as H1N1. In 2011, a new swine flu virus was detected. The new strain was named influenza A (H3N2)v. Only a few people (*mainly children*) were first infected. Unfortunately, another virus termed H3N2 (*note no "v" in its name*) has been detected and caused flu, but this strain is different from H3N2v. In general, all of the influenza A viruses have a structure similar to the H1N1 virus; each type has a somewhat different H and/or N structure.

Why is swine flu now infecting humans?

Many researchers now consider that two main series of events can lead to swine flu (and also avian or bird flu) becoming a major cause for influenza illness in humans.

- First, the influenza viruses (types A, B, C) are enveloped RNA viruses with a segmented genome; this means the viral RNA genetic code is not a single strand of RNA but exists as eight different RNA segments in the influenza viruses.
- A human (or bird) influenza virus can infect a pig respiratory cell at the same time as a swine influenza virus; some of the replicating RNA strands from the human virus can get mistakenly enclosed inside the enveloped swine influenza virus.
- Second, pigs can play a unique role as an intermediary host to new flu types because pig respiratory cells can be infected directly with bird, human, and other mammalian flu viruses.

Polio

Q: Describe different causes and preventions of 'Polio' (CSS-2018)

Poliomyelitis (polio) is a highly infectious viral disease, which mainly affects young children. The virus is transmitted by person-to-person spread mainly through the faecal-oral route or, less frequently, by a common vehicle (e.g. contaminated water or food) and multiplies in the intestine, from where it can invade the nervous system and can cause paralysis.

Symptoms

Polio is a highly infectious disease caused by a virus. It invades the nervous system, and can cause total paralysis in a matter of hours. Initial symptoms are fever, fatigue, headache, vomiting, stiffness of the neck and pain in the limbs. 1 in 200 infections leads to irreversible paralysis (usually in the legs). Among those paralysed, 5% to 10% die when their breathing muscles become immobilized.

People most at risk

Polio mainly affects children under 5 years of age.

Prevention

There is no cure for polio, it can only be prevented. Polio vaccine, given multiple times, can protect a child for life.

How Is Polio Spread?

Polio is a highly contagious illness that can spread easily from person to person. How is polio spread? In most cases, polio is spread through contact with stool from an infected person (for example, eating food that is contaminated with poliovirus). Less commonly, polio transmission occurs through contact with respiratory droplets or saliva.

Polio is a highly contagious illness that can spread easily from person to person. In fact, when a person is infected with polio, it is expected that polio transmission among susceptible household contacts will occur in nearly 100 percent of children and over 90 percent of adults.

Polio is also known as:

- Poliomyelitis
- Infantile paralysis
- Polio disease.
- When a person is infected with poliovirus, the virus resides in the intestinal tract and mucus in the nose and throat. Poliovirus transmission most often occurs through contact with stool of this infected person (known as fecal-oral transmission). Less frequently, polio transmission can occur through contact with infected respiratory secretions or saliva (oral-oral transmission).

Fecal-Oral Polio Transmission

Polio transmission most often occurs through contact with stool from an infected person. This spread of poliovirus can happen in one of several ways, which include:

- Eating food or drinking liquids that are contaminated with poliovirus. Poliovirus is commonly found in sewage water.
- Touching surfaces or objects contaminated with poliovirus (for instance, by changing diapers), and then placing the contaminated hand in the mouth.
- Sharing foods or eating utensils with someone infected with poliovirus.

Oral-Oral Polio Transmission

Less commonly, polio transmission occurs through contact with respiratory droplets or saliva. When an infected person sneezes or coughs, droplets spray into the air. The infected mucus or saliva can land in other people's noses or throats when they breathe or put their fingers in their mouth, nose, or eyes after touching an infected surface.

Polio Vaccination

There are two types of vaccinations for polio, which are used to prevent the disease. One type is an inactivated vaccination, which contains no live poliovirus. It is given as a shot in the arm or leg, depending on the person's age. The other type is the oral vaccination, which contains live but weakened poliovirus.

A polio vaccination is a medicine that is given for polio prevention. There are two general types. One type is an inactivated vaccine (the IPV), which contains no live poliovirus. The other is a live oral vaccination, which contains live but

AIDS

On June 5, 1981, an article concerning five previously healthy, young gay men in Los Angeles diagnosed with *Pneumocystis carinii pneumonia*, an infection that usually appears only in individuals with substantial immune system damage, appeared in the *Morbidity and Mortality*

Weekly Report, a publication of the Centers for Disease Control and Prevention (CDC).

Soon, more cases like these appeared, at first mainly in gay men, but then also in injection drug users, hemophiliacs, and other recipients of blood and blood products, heterosexual men and women, and babies who acquired the infection from their mothers during birth or breastfeeding. We and our colleagues quickly began to confront the reality of a deadly new disease that would change the world. The disease ultimately would be referred to as AIDS.

The word **AIDS** stands for *Acquired Immuno Deficiency Syndrome*. AIDS is a medical diagnosis for a combination of symptoms, which results from a breakdown of the immune system. '**A**' stands for acquired which means that it is obtained or received by a person and is something, which is not genetically inherited. '**ID**' stands for Immuno Deficiency which means there is deficiency in the immune system or that the immune system is weakened. '**S**' stands for syndrome that stands to emphasize that AIDS is not just one disease or symptom but presents as a group of diseases or symptoms.

AIDS is caused by the Human Immuno deficiency Virus (HIV), a member of a group of viruses called retrovirus, which have an envelope enclosing the RNA genome. Transmission of HIV-infection generally occurs by

a) Sexual contact with infected person.
b) By transfusion of contaminated blood and blood products.
c) By sharing infected needles as in the case of intravenous drug abusers and
d) From infected mother to her child through placenta.

It is important to note that HIV/AIDS is not spread by mere touch or physical contact; it spreads only through body fluids. It is, hence, imperative, for the physical and psychological well-being, that the HIV/AIDS infected persons are not isolated from family and society. There is always a time-lag between the infection and appearance of AIDS symptoms. This period may vary from a few months to many years (usually 5-10 years).

Symptoms

HIV may not cause symptoms early on. People who do have symptoms may mistake them for the flu or mono. Common early symptoms include:

- Fever.
- Sore throat.
- Headache.
- Muscle aches and joint pain.
- Swollen glands (swollen lymph nodes).
- Skin rash.

Symptoms may appear from a few days to several weeks after a person is first infected. The early symptoms usually go away within 2 to 3 weeks.

After the early symptoms go away, an infected person may not have symptoms again for many years. Without treatment, the virus continues to grow in the body and attack the immune system. After a certain point, symptoms reappear and then remain. These symptoms usually include:

- Swollen lymph nodes.
- Extreme tiredness.
- Weight loss.
- Fever.
- Night sweats.

Diagnosis / Treatment

A widely used diagnostic test for AIDS is enzyme linked Immuno-sorbent assay (ELISA). Treatment of AIDS with anti-retroviral drugs is only partially effective. They can only prolong the life of the patient but cannot prevent death, which is inevitable.

Prevention of AIDS

As AIDS has no cure, prevention is the best option.

- The only excuse may be ignorance and it has been rightly said – "don't die of ignorance".
- In Pakistan National Aids Control Program (NACP) and other non-governmental organisation (NGOs) are doing a lot to educate people about AIDS.

Cancer

Cancer is one of the most dreaded diseases of human beings and is a major cause of death all over the globe.

The mechanisms that underlie development of cancer or oncogenic transformation of cells, its treatment and control have been some of the most intense areas of research in biology and medicine. In our body, cell growth and differentiation is highly controlled and regulated. In cancer cells, there is breakdown of these regulatory mechanisms. Normal cells show a property called contact inhibition by virtue of which contact with other cells inhibits their uncontrolled growth.

Cancer cells appear to have lost this property. As a result of this, cancerous cells just continue to divide giving rise to masses of cells called tumors.

Tumors are of two types: benign and malignant.

- **Benign tumors** normally remain confined to their original location and do not spread to other parts of the body and cause little damage.
- **The malignant tumors**, on the other hand are a mass of proliferating cells called neoplastic or tumor cells.

These cells grow very rapidly, invading and damaging the surrounding normal tissues. As these cells actively divide and grow they also starve the normal cells by competing for vital nutrients.

Cells sloughed from such tumors reach distant sites through blood, and wherever they get lodged in the body, they start a new tumor there. This property called metastasis is the most feared property of malignant tumors.

Causes of cancer:

Transformation of normal cells into cancerous neoplastic cells may be induced by physical, chemical or biological agents. These agents are called carcinogens.

- Ionizing radiations like X-rays and gamma rays and non-ionizing radiations like UV cause DNA damage leading to neoplastic transformation.
- The chemical carcinogens present in tobacco smoke have been identified as a major cause of lung cancer.
- Cancer causing viruses called oncogenic viruses have genes called viral oncogenes.
- Furthermore, several genes called cellular oncogenes(c-onc) or proto oncogenes have been identified in normal cells which, when activated under certain conditions, could lead to oncogenic transformation of the cells.

Cancer detection and diagnosis:

Cancer detection is based on biopsy and histopathological studies of the tissue and blood and bone marrow tests for increased cell counts in the case of leukemias.

- In biopsy, a piece of the suspected tissue cut into thin sections is stained and examined under microscope (histopathological studies) by a pathologist.
- Techniques like radiography (use of X-rays), CT (computed tomography) and MRI (magnetic resonance imaging) are very useful to detect cancers of the internal organs. Computed tomography uses X-rays to generate a three-dimensional image of the internal of an object. MRI uses strong magnetic fields and non-ionizing radiations to accurately detect pathological and physiological changes in the living tissue.
- Antibodies against cancer-specific antigens are also used for detection of certain cancers. Techniques of molecular biology can be applied to detect genes in individuals with inherited susceptibility to certain cancers. Identification of such genes, which predispose an individual to certain cancers, may be very helpful in prevention of cancers.

Treatment of cancer:

In radiotherapy, tumor cells are irradiated lethally, taking proper care of the normal tissues surrounding the tumor mass.

Most cancers are treated by combination of surgery, radiotherapy and chemotherapy.

Common Diseases in Human

Malaria

Malaria is a blood disease caused by a parasite that is transmitted from human-to-human by the Anopheles mosquito. Malaria is a preventable and treatable disease.

Symptoms of Malaria (Early stage symptoms of Malaria) .A high temperature (fever), Chills, Headache, Sweats, Tiredness (fatigue), Nausea, Vomiting (Other common symptoms may include) Dry cough, Back pain, Muscle ache, Enlarged spleen

Cure / prevention: Administration of quinine or plaurdine. Prevented by keeping the atmosphere free from mosquitoes

Tuberculosis (TB)

Tuberculosis (TB) is an infectious disease that is caused by bacterium called Mycobacterium tuberculosis. TB primarily affects the lungs, but it can also affect organs in the central nervous system, lymphatic system, and circulatory system among others. The disease was called "consumption" in the past because of the way it would consume from within anyone who became infected.

Causes Tuberculosis is ultimately caused by the Mycobacterium tuberculosis that is spread from person to person through airborne particles.

Symptoms: specific to the lungs include coughing that lasts for 3 or more weeks, coughing up blood, chest pain, and pain with breathing or coughing.

Cure / prevention: Streptomycin and surgery. Prevented by BCG inoculation and healthy living and working atmosphere. BCG the vaccine was developed in 1906 by Guerin in Paris and called BCG.

Cholera

Cholera is an infectious disease that causes severe watery diarrhea, which can lead to dehydration and even death if untreated. It is caused by eating food or drinking water contaminated with a bacterium called Vibrio cholerae.

Causes: Cholera vibrio or vibriocholerae which attacks during exposing to chill, whenstomach is empty for long duration, eating of unripe or overripe fruits and stale food

Symptoms: Vomitting, stomachache, loose stools with •high frequency follwed by temperature and unconsciousness

Cure/prevention: Avoiding consumption of cut fruits exposed to files and contaminated water .Anti cholera drugs are administered.

Diphtheria

Diphtheria is a contagious illness caused by a type of bacteria. It can cause breathing and swallowing problems and can damage the heart and central nervous system (brain and spinal cord).

Causes: Diphtheria is a infection caused by Corynebacterium diphtheriaebacteria.

Symptoms: When the bacteria that cause diphtheria invade the respiratory system, they produce a poison (toxin) that can cause: Weakness, Sore throat, Fever, Swollen glands in the neck

Cure / prevention: Immunization vaccine / injection of diphtheria antitoxinwithin 12-24 hours of appearance and symptoms

Tetanus

Tetanus is a dangerous nerve ailment caused by the toxin of a common bacterium, Clostridium tetani.

Causes: Bacillus tetanus and clostridum tetani which live in soil, dust, cow and horse dung.It attacks an open wound exposed to dust and soil

Symptoms : Tetanus is often called "lockjaw" because the jaw muscles tighten, and the person cannot open his mouth.Headache , Jaw cramping , Sudden, involuntary muscle tightening – often in the stomach (muscle spasms) , Painful muscle stiffness all over the body , Trouble swallowing , Jerking or staring (seizures) , Fever and sweating , High blood pressure and fast heart rate

Cure / prevention: Preventing exposed of wounds to dust and administering to anti-tetanus (ATS) injection

Typhoid

A food and water-borne infectious disease

Cause: Salmonella typhi bacillus transmitted through contaminated food and water, either directly by sewage or indirectly by hands and faulty hygiene.

Symptoms: *Temperature, slow pulse, abdominal tenderness, rose-coloured rash*

Cure / prevention: Rest and administration of Chloromycetin, proper sanitation, protection of eatables.

Plague

A contagious disease which takes the form of an epidemic

Cause: Pasteurella pestis spread by infected rats, Transfer of infection from rat to man through flea bite or accidental contact with infected rats

Symptoms: *a cute baby ache, reddish eyes, sudden rise of temperature, inflammation of neck glands and glands in armpit and thighs.*

Cure / prevention: Antiplague inoculation, isolation of patient, disinfection of patient s clothes and utensils, burning of killed rats.Sulpha drugs and streptomycine administration.

Typhus

A viral infection

Cause: Rickettsia prowazekii, usually caused by poor hygiene and malnutrition

Symptoms: High fever, skin eruption and severe headache

Cure / prevention: Sulphonamides and antibiotics

Pneumonia

Cause: Diplococus Pneumonia

Symptoms: Chills, pain in chest, rusty sputum, rapid breathing, abdominal pain

Cure / prevention: Antibiotics

Environmental Science

Environment is defined as the surroundings in which the organism lives. The environment may be the physical environment, the chemical environment or the biological environment. Thus, the environment has two components - abiotic and biotic. The abiotic environment includes the air (*atmosphere*), water (*hydrosphere*) and land (*lithosphere*). The biotic environment includes the plants, animals and the microbes.

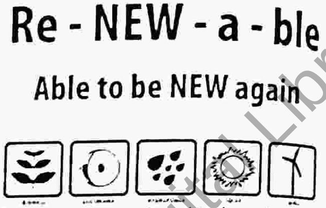
Organisms are dependent on the environment to fulfil their needs, man is also constantly interacting with the environment in order to fulfil his needs. These needs include the basic needs of oxygen, food and shelter in addition to the social needs like entertainment, medicines, etc. The things that man requires for his survival and comfort are called the resources. The environment is a reservoir of resources. For survival of man. It is very important environment. Maintaining the natural resources of the environment and their careful use is called conservation. The conservation of environment involves the conservation of the natural resources.

Classification of Natural Resources

The resources may be classified in two ways:

1 Renewable resources
2 Non-renewable resources

Renewable Resources


Re - NEW - a - ble
Able to be NEW again

The resources that can be replenished by the environment are called the renewable resources. These are also called the inexhaustible resources. These resources are constantly recycled in the environment like water. This also includes resources like the solar energy, air, plants, animals, microbes and some minerals like nitrogen. The rates at which these resources are returned to the environment are different for different resources. The rate at which man uses them also varies.

Non-Renewable Resources

NON - Re - NEW - a - ble
NOT Able to be NEW again
U 235

The resources that cannot be replenished by the environment are called the non-renewable resources. These are also called the exhaustible resources. These resources are formed in the environment at a very slow pace and cannot be replenished at the rate at which they are used. They include fossil fuels such as coal and petroleum and most of the minerals. Coal and petroleum, for instance take millions of years to be formed as they are formed from the fossils. Thus, they can never be replaced.

Differences *between* Renewable Resources *and* Non-Renewable Resources

Renewable Resources	Non-Renewable Resources
Renewable resources are resources that can be produced naturally	Nonrenewable resources are resources that cannot be replaced.
Renewable resources do not get exhausted with use, such as farm crops or trees, which can be harvested and then grow back and renew themselves cycle after cycle.	Non-Renewable energy sources exhausted with use Nonrenewable ones produce or grow once, after which they are harvested and die completely.
Renewable resources are not affected by the human activities	Nonrenewable resources are affected by human activities
All biotic resources are renewable. For example: air and water.	Some abiotic resources are non-renewable. For example-fossil fuels and minerals.
A renewable resource is a naturally sustainable product, it can be used without fear of running out so to speak. Things like wind power, solar power and wave power are renewable, the wind will always blow, the sun will always shine and the tides will keep coming	Non-Renewable resources on the other hand, although naturally occurring are not sustainable. Things like fossil fuels, gas, oil and coal, we would use up those resources long before they could ever be replaced naturally.
Renewable resources are resources that renew themselves like animals. They give birth to a new animal, then it keeps on going so animals are always going to be here	Nonrenewable resources are things that cant renew themselves and might run out
Renewable resources are resources that renew themselves like animals. They give birth to a new animal, then it keeps on going so animals are always going to be here.	Nonrenewable resources are things that cant renew themselves and might run out.

Atmosphere

The atmosphere is the mixture of gas molecules and other materials surrounding the earth. The principal constituents of the atmosphere of Earth are nitrogen (78 percent) and oxygen (21 percent). The atmospheric gases in the remaining 1 percent are argon (0.9 percent), carbon dioxide (0.03 percent), varying amounts of water vapor, and trace amounts of hydrogen, ozone, methane, carbon monoxide, helium, neon, krypton, and xenon.

The study of the atmosphere is called meteorology.

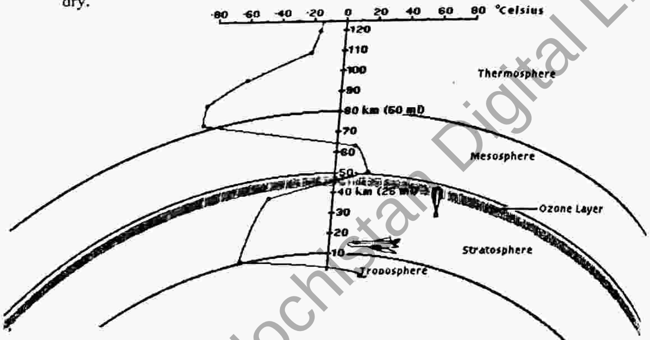
Layers *of the* Atmosphere

The atmosphere is divided into layers based on temperature, composition and electrical properties. These layers are approximate and the boundaries vary, depending on the seasons and latitude. (*The boundaries also depend on which "authority" is defining them.*)

Layers Based *on* Composition

Homosphere

- The lowest 100 km (60 miles), including the Troposphere, Stratosphere and Mesosphere.
- Contains 99% of the atmosphere's mass.
- Molecules do not stratify by molecular weight.
- Although small local variations exist, it has a relatively uniform composition, due to continuous mixing, turbulence and eddy diffusion.
- Water is one of two components that is not equally distributed. As water vapor rises, it cools and condenses, returning to earth as rain and snow. The Stratosphere is extremely dry.



- Ozone is another molecule not equally distributed.

Heterosphere

- Extends above Homosphere, including the Thermosphere and Exosphere.
- Stratified (components are separated in layers) based on molecular weight. The heavier molecules, like nitrogen and oxygen, are concentrated in the lowest levels. The lighter ones, helium and hydrogen, predominate higher up.

Layers Based *on* Electrical Properties

Neutral atmosphere

- Below about 100 km (60 miles)

Ionosphere

- Above about 100 km
- Contains electrically charged particles or ions, created by the absorption of UV (ultraviolet) light.
- The degree of ionization varies with altitude.
- Different layers reflect long and short radio waves. This allows radio signals to be sent around the curved surface of the earth.
- The Aurora Borealis and Aurora Australis (the Northern and Southern Lights) occur in this layer.
- The **Magnetosphere** is the upper part of the ionosphere, extending out to 64,000 km (40,000 miles.) It protects us from the high energy, electrically charged particles of the solar wind, which are trapped by the Earth's magnetic field.

Layers Based *on* Temperature

Troposphere *Height depends on the seasons and latitude. It extends from ground level about 16 km (10 miles) at the equator, and to 9 km (5 miles) at the North and South up to Poles.*

- The prefix "tropo" means change. Changing conditions in the Troposphere result in our weather.
- Temperature decreases with increasing altitude. Warm air rises, then cools and falls back to Earth. This process is called convection, and results in huge movements of air. Winds in this layer are mostly vertical.
- Contains more air molecules than all the other layers combined.

Stratosphere *Extends out to about 50 km (30 miles)*

- The air is very thin.
- The prefix "strato" is related to layers, or stratification.
- The bottom of this layer is calm. Jet planes often fly in the lower Stratosphere to avoid bad weather in the Troposphere.
- The upper part of the Stratosphere holds the high winds known as the jet streams. These blow horizontally at speeds up to 480 km/hour (300 miles/hour)
- Contains the "ozone layer" located between 15 - 40 km (10 - 25 miles) above the surface. Although the concentration of ozone is at most 12 parts per million (ppm), it is very effective at absorbing the harmful ultraviolet (UV) rays of the sun and protecting life on Earth. Ozone is a molecule made of three oxygen atoms. The oxygen molecule we need to breathe contains two oxygen atoms.
- The temperature is cold, about -55 °C (-67 °F) in the lower part, and increases with increasing altitude. The increase is caused by the absorption of UV radiation by the oxygen and ozone.
- The temperature increase with altitude results in a layering effect. It creates a global "inversion layer", and reduces vertical convection.

Mesosphere - *Extends out to about 100 km (65 miles)*

- Temperature decreases rapidly with increasing altitude.

Thermosphere - *Extends out to about 400 km (250 miles)*

- Temperature increases rapidly with increasing altitude, due to absorption of extreme short wavelength UV radiation.
- Meteors, or "shooting stars," start to burn up around 110-130 km (70-80 miles) above the earth.

Exosphere -*Extends beyond the Thermosphere hundreds of kilometers, gradually fades into interstellar space.*

- Density of the air is so low that the normal concept of temperature loses its meaning.
- Molecules often escape into space after colliding with one another.

Hydrosphere

What is the Hydrosphere?

The hydrosphere is the liquid water component of the Earth. It includes the oceans, seas, lakes, ponds, rivers and streams. The hydrosphere covers about 70% of the surface of the Earth and is the home for many plants and animals.

The hydrosphere, like the atmosphere, is always in motion. The motion of rivers and streams can be easily seen, while the motion of the water within lakes and ponds is less obvious. Some of the motion of the oceans and seas can be easily seen while the large scale motions that move water great distances such as between the tropics and poles or between continents are more difficult to see. These types of motions are in the form of currents that move the warm waters in the tropics toward the poles, and colder water from the Polar Regions toward the tropics. These currents exist on the surface of the ocean and at great depths in the ocean (up to about 4km).

The characteristics of the ocean which affects its motion are its temperature and salinity. Warm water is less dense or lighter and therefore tends to move up toward the surface, while colder water is more dense or heavier and therefore tends to sink toward the bottom. Salty water is also more dense or heavier and thus tends to sink, while fresh or less salty water is less dense or lighter and thus tends to rise toward the surface. The combination of the water's temperature and salinity determines whether it rises to the surface, sinks to the bottom or stays at some intermediate depth.

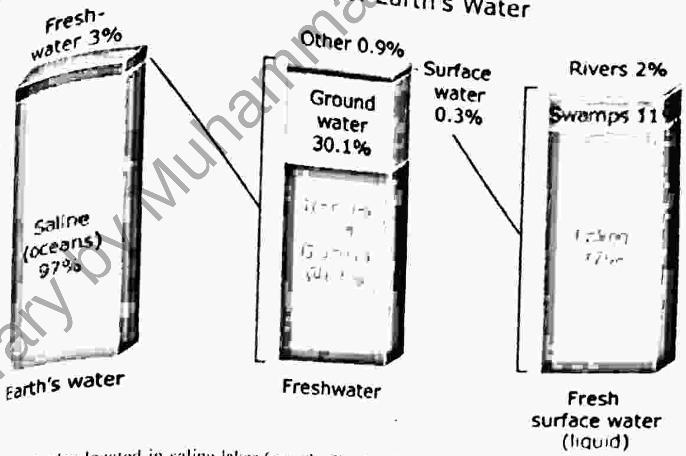
The oceans currents are also affected by the motion of the atmosphere, or winds, above it. The energy in the wind gets transferred to the ocean at the ocean surface affecting the motion of the water there. The effect of wind is largest at the ocean surface.

The ocean serves two main purposes in the climate system. First, it is a large reservoir of chemicals that can contribute to the greenhouse effect in the atmosphere and energy absorbing 90% of the solar radiation which hits the surface. This reservoir changes very slowly limiting how fast the climate can change. Second, it works with the atmosphere to redistribute the energy received from the sun such that the heat in the topics, where a lot of energy is received from the sun, is transferred toward the poles, where heat is generally lost to space.

Global Water Distribution

The definition of freshwater is water containing less than 1000 milligrams per liter of dissolved solids, most often salt. The global distribution of freshwater resources varies greatly from region to region An 'inventory' of Earth's waters shows that approximately 97% of the global water supply is found in the oceans, which are saline. A very small amount of salty water is also located in saline lakes (e.g., the Caspian Sea). The remaining water inventory (3%) is 'freshwater'. Permanent ice (e.g., continental and mountain glaciers) is the largest freshwater storage on Earth, accounting for about 2% of the total global supply - or nearly 69% of the total freshwater supply. Freshwater is also found beneath the Earth's surface as groundwater (approximately 30% of the total freshwater supply) and in surface water storages such as lakes, streams, swamps and marshes. Minute amounts of freshwater are also stored in the soil, theatmosphere and in biological organisms.

Distribution of Earth's Water



Percentage Vs Volume Water

Water Source	Water Volume (in cubic kilometres)	% of Fresh Water	% of Total Water	No. of Olympic-Sized Swimming Pools (total water)
Oceans, Seas and Bays	1,338,000,000	--	96.5	5300 trillion
Ice caps, Glaciers & Permanent snow	24,064,000	68.7	1.74	9.6 trillion
Groundwater (total)	23,400,000	--	1.70	9.3 trillion
Groundwater (fresh)	10,530,000	30.1	0.76	4.2 trillion
Groundwater (salt)	12,870,000	--	0.94	5.1 trillion
Lakes (total)	176,400	--	0.013	70,000 million
Lakes (fresh)	91,000	0.26	0.007	36,000 million
Lakes (salt)	85,400	--	0.006	34,000 million

Atmosphere	12,900	0.04	0.001	5,100 million
Swamps	11,470	0.03	0.0008	4,500 million
Rivers	2,120	0.006	0.0002	840 million

As you can see most of the water on Earth is located in oceans, seas and bays with rivers containing an extremely small amount of the total water on Earth. Oceans, seas and bays alone contain the same amount of water as 5300 trillion Olympic-sized swimming pools. This is enough water to cover just the area of the Central Coast, which has an area of 1772.9km2, to a depth of 755,000km which would stretch to the moon and back twice!! It is important to note at this point that oceans, seas and bays are not fresh water bodies and icecaps and glaciers contain water that humans cannot get access to. This means that according to this graph the best water supply on Earth comes from our groundwater resources with our lake systems the next best option. Fresh groundwater sources worldwide contain approximately 10,530,000km3 of water or 4.2 trillion Olympic-sized swimming pools. This amount of water would cover the Central Coast in a depth of 5939km of water.

Why does Fresh Water need our protection?

- Water is life. It's vital. It supports the immense diversity of life on Earth. It's a source of food, health and energy.
- Fresh water makes civilization possible.
- But fresh water, in turn, isn't possible without a healthy planet — and human actions are putting a healthy planet at risk.
- The ultimate source of fresh water is rain and snow.
- Freshwater systems are the rivers, streams, lakes, ponds, groundwater, cave water, springs, floodplains, and wetlands (bogs, marshes, and swamps)
- Freshwater provides water for drinking, sanitation, agriculture, transport, electricity generation and recreation. It also creates habitats for a diverse range of animals and plants.
- We cannot live without freshwater.
- Safe drinking water is fundamental to healthy lives and prosperous communities. Every person needs 20 to 40 liters of freshwater per day for drinking, cooking, and sanitation needs alone. Yet some 1.1 billion people world-wide do not have access to safe, clean drinking water. As a result, many people become sick, some lives are shortened, and some die.
- Half of the world's hospital beds are filled with people suffering from water-borne diseases. According to the World Health Organization, each year, an estimated 4 billion people get sick with diarrhea as a result of drinking unsafe water. More than 2 million of them die; mostly children under the age of 5, most of them poor, and most of them living in the developing world.

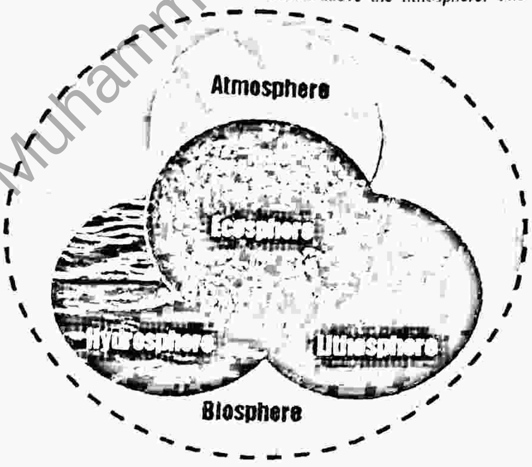
Biosphere

What is the biosphere?

The biosphere is simply the home of all known life that has ever existed in the entire universe.

The biosphere is made up of the parts of Earth where life exists. The biosphere extends from the deepest root systems of trees, to the dark environment of ocean trenches, to lush rain forests and high mountaintops.

Scientists describe the Earth in terms of spheres. The solid surface layer of the Earth is the lithosphere. The atmosphere is the layer of air that stretches above the lithosphere. The Earth's water—on the surface, in the ground, and in the air—makes up the hydrosphere.



Since life exists on the ground, in the air, and in the water, the biosphere overlaps all these spheres. Although the biosphere measures about 20 kilometers (12 miles) from top to bottom, almost all life exists between about 500 meters (1,640 feet) below the ocean's surface to about 6 kilometers (3.75 miles) above sea level.

Origin of the Biosphere

The biosphere has existed for about 3.5 billion years. The biosphere's earliest life-forms, called prokaryotes, survived without oxygen. Ancient prokaryotes included single-celled organisms such as bacteria and archaea.

Some prokaryotes developed a unique chemical process. They were able to use sunlight to make simple sugars and oxygen out of water and carbon dioxide, a process called photosynthesis. These photosynthetic organisms were so plentiful that they changed the biosphere. Over a long period of time, the atmosphere developed a mix of oxygen and other gases that could sustain new forms of life.

The addition of oxygen to the biosphere allowed more complex life-forms to evolve. Millions of different plants and other photosynthetic species developed. Animals, which consume plants (and other animals) evolved. Bacteria and other organisms evolved to decompose, or break down, dead animals and plants.

The biosphere benefits from this food web. The remains of dead plants and animals release nutrients into the soil and ocean. These nutrients are re-absorbed by growing plants. This exchange of food and energy makes the biosphere a self-supporting and self-regulating system.

The biosphere is sometimes thought of as one large ecosystem—a complex community of living and nonliving things functioning as a single unit. More often, however, the biosphere is described as having many ecosystems.

Biosphere Reserves

People play an important part in maintaining the flow of energy in the biosphere. Sometimes, however, people disrupt the flow. For example, in the atmosphere, oxygen levels decrease and carbon dioxide levels increase when people clear forests or burn fossil fuels such as coal and oil. Oil spills and industrial wastes threaten life in the hydrosphere. The future of the biosphere will depend on how people interact with other living things within the zone of life.

In the early 1970s, the United Nations established a project called Man and the Biosphere Programme (MAB), which promotes sustainable development. A network of biosphere reserves exists to establish a working, balanced relationship between people and the natural world.

Currently, there are 563 biosphere reserves all over the world. The first biosphere reserve was established in Yangambi, Democratic Republic of Congo. Yangambi, in the fertile Congo River Basin, has 32,000 species of trees and such endemic species as forest elephants and red river hogs. The biosphere reserve at Yangambi supports activities such as sustainable agriculture, hunting, and mining.

One of the newest biosphere reserves is in Yayu, Ethiopia. The area is developed for agriculture. Crops such as honey, timber, and fruit are regularly cultivated. However, Yayu's most profitable and valuable resource is an indigenous species of plant, *Coffea arabica*. This shrub is the source of coffee. Yayu has the largest source of wild *Coffea arabica* in the world.

Earth

Earth is our home planet. Scientists think Earth formed billions of years ago. Four planets in the solar system are bigger than Earth. Three planets are smaller. It is the third-closest planet to the sun. Only Mercury and Venus are closer.

Earth is the only planet known to have lots of liquid water. Liquid water is important for life. Earth is the only planet where life has been found.

Composition *and* Internal Structure *of the* Earth

(CSS 1997, 2003)

Any group of diverse materials can be classified by chemistry or physical properties. Chemistry refers to different materials, and physical properties refers to such things as whether the materials are solids or liquids, etc. Some physical layers in the earth consist of 2 chemical layers and some chemical layers consist of 2 physical layers.

Structure of the Earth

In outward appearance, the earth is a nearly spherical ball with a radius of 6371 kilometers. Internally, the earth consists of three major layers. They are:

- Crust
- Mantle
- Core

The Earth's Crust

A crust is the outermost layer of a planet. The crust of the Earth is composed of a great variety of igneous, metamorphic, and sedimentary rocks. The crust is underlain by the mantle

The upper part of the mantle is composed mostly of peridotite, a rock denser than rocks common in the overlying crust.

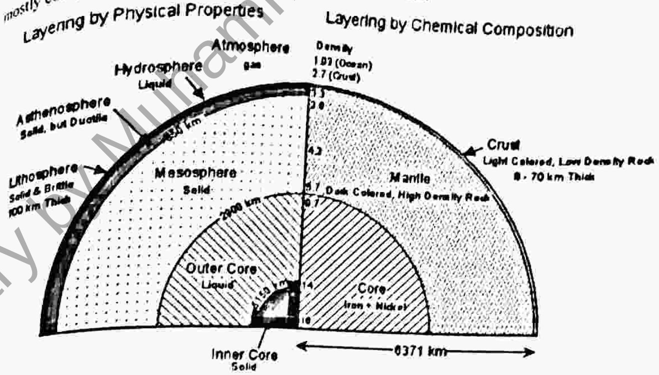
The boundary between the crust and mantle is conventionally placed at the Mohorovicic discontinuity, a boundary defined by a contrast in seismic velocity.

Earth's crust occupies less than 1% of Earth's volume. The oceanic crust of the Earth is different from its continental crust.

The oceanic crust is 5 km (3 mi) to 10 km (6 mi) thick and is composed primarily of basalt, diabase, and gabbro.

The continental crust is typically from 30 km (20 mi) to 50 km (30 mi) thick, and it is

mostly composed of less dense rocks than is the oceanic crust.



The crust is made up of three kinds of rocks - igneous, sedimentary and metamorphic. All rocks on the earth's surface are made of minerals. Minerals are the most common solid materials found on earth. Minerals are themselves made up of basic chemical substances called elements. Rocks in the earth's crust consist mostly of two elements - silicon and oxygen. The next most common elements in the earth's crust are aluminium, iron, calcium, sodium and magnesium - in the decreasing order of abundance.

Mohorovicic discontinuity or Moho / Mantle

Beneath the Earth's crust, the outermost hard shell that makes up just 1 percent of the volume of the planet lies a hot, viscous layer of rock called the mantle.

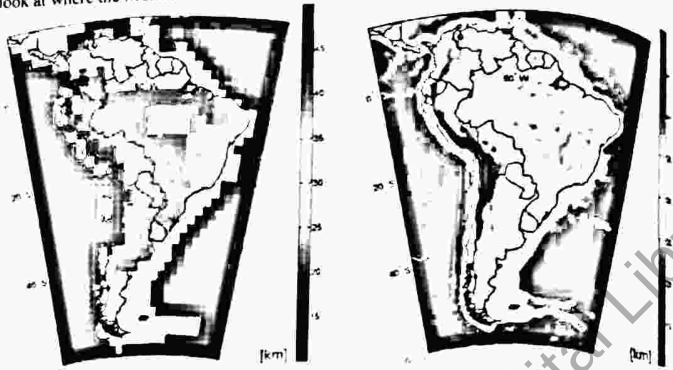
The mantle was completely unknown to science just a century ago, until Croatian seismologist Andrija Mohorovicic noticed in 1909 that seismic waves from earthquakes changed speed about 30 miles (50 kilometers) below the planet's surface. The spot of this sudden change marks the boundary between the crust and mantle, known in Mohorovicic's honor as the **Mohorovicic discontinuity, or Moho.**

Even today, the Moho is difficult to study, with geologists using two main methods: seismic and gravimetric. Seismic is the way Mohorovicic first learned of the Moho's existence: seeing how seismic waves alter their speed and direction as they move from one layer of the Earth to another. The waves change because the properties of the rocks they are travelling through change, much like the way light bends as it travels through a crystal. Gravimetry looks at the gravitational effect that the rocks under different parts of the Earth have due to their differing densities that in turn are a result of different rock compositions. But models of the Moho made from both methods are generally limited by poor data coverage.

New High Res Maps Peer beneath Earth's Surface

Now, a new effort using the gravimetric approach with data from the European Spa Agency's GOCE gravity satellite has now generated the first global high-resolution map of the boundary between Earth's crust and mantle.

The project — known as GEMMA (for GOCE *Exploitation for Moho Modelling and Applications*) — uses GOCE's more widespread and homogeneous data to provide a much clea look at where the Moho sits.



Comparison between an old global Moho model (left) based on seismic/gravity data and Moho-mapping based on GOCE data (right) in South America.

The project — known as GEMMA (for GOCE Exploitation for Moho Modelling and Applications) — uses GOCE's more widespread and homogeneous data to provide a much clearer look at where the Moho sits.

The map shows that the Moho exists at a depth of about 40 miles (70 km) under mountainous regions such as the Himalayas, but is at a much shallower 6-mile (10 km) depth under the oceans.

The mantle is a thick layer of rock below the crust. It is the central region between the crust and the core of the earth. It is about 2,900 km deep. The rock in the mantle is made of silicon, oxygen, aluminium, iron and magnesium. The upper part of the mantle has a temperature of about 870⁰ C.

Together, the crust and upper portion of the mantle — called the lithosphere — are where most important geological processes occur, such as mountain-building, earthquakes and the source of volcanoes. The slow churning and overturning of the mantle is what drives the movements of Earth's tectonic plates.

This temperature gradually increases down through the mantle to about 4400⁰ C. The pressure inside the mantle increases with depth. Even under high pressure in the mantle, the rocks are usually in the solid state. Under extreme pressures and temperatures, however, some of the rocks near the bottom of the mantle tend to flow like coal tar. The density of mantle increases

ually as we go downwards. In the beginning of mantle, the density is about 4g/cm³. It goes on creasing until it reaches a value of about 6g/cm³ at the bottom of the mantle. Here, the mantle ends and a sudden increase in density occurs. It is here that the core of the earth begins

The core

The last layer is the *core*, which is separated into the liquid outer core and the solid inner core. The outer core is 2300 km thick and the inner core is 1200 km thick. The outer core is composed mainly of a nickel-iron alloy, while the inner core is almost entirely composed of iron. The inner core may have a temperature up to about 7,200°C, which is hotter than the surface of the Sun. The outer core is composed mainly of a nickel-iron alloy, while the inner core is almost entirely composed of iron. Earth's magnetic field is believed to be controlled by the liquid outer core

The Earth is separated into layers based on mechanical properties in addition to composition. The topmost layer is the lithosphere, which is comprised of the crust and solid portion of the upper mantle. The lithosphere is divided into many plates that move in relation to each other due to tectonic forces. The lithosphere essentially floats atop a semi-liquid layer known as the asthenosphere. This layer allows the solid lithosphere to move around since the asthenosphere is much weaker than the lithosphere.

The Earth is formed of three concentric layers: the *core*, the *mantle* and the *crust*, these are separated by transition zones called discontinuities

	Thickness *(km)*	Density *(g/cm³)*		Types of rock found
		Top	Bottom	
Crust	**30**	**2.2**	**2.9**	**Silicic rocks.** **Andesite, basalt at base**
Upper Mantle	720	3.4		Peridotite, eclogite, olivine, spinel, garnet, pyroxene
			4.4	Perovskite, oxides
Lower Mantle	**2,171**	**4.4**	**5.6**	**Magnesium and silicon oxides**
Outer Core	2,259	9.9	12.2	Iron + oxygen, sulfur, nickel alloy
Inner Core	**1,221**	**12.8**	**13.1**	**Iron + oxygen, sulfur, nickel alloy**
Total Thickness	6,401			

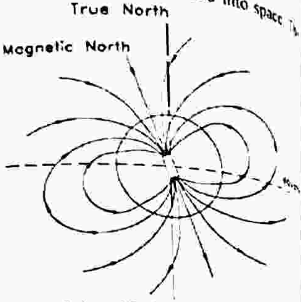
Magnetic Field *of the* Earth

The Earth is a giant magnet. Its hot liquid centre core contains iron, and as it moves, it creates an electric current that causes a magnetic field around the Earth. The Earth has a north and south magnetic pole

These poles aren't quite lined up with the geographic North and South Poles on a map. Because the moving inner core's poles are always wandering around.

The north magnetic pole is currently situated near Bathurst Island in northern Canada, about 1600 km from the North Pole. The south magnetic pole is near the Adélie Coast on the continent of Antarctica, about 2600 km from the South Pole. Both pole positions can wander up to 10 km per year

Because the Earth has a field just like a magnet, it attracts things. In particular, it will attract a small magnetised needle. A needle mounted in a case that lets it move freely will po the north magnetic pole. We call this needle a compass



Earth's magnetic field extends thousands of kilometers (miles) outward into space. Th field forms a gigantic magnetic "bubble" in space around Earth. This magnetic bubble is called the magnetosphere. Earth's magnetosphere shields our planet from most particle radiation that flows our way from the Sun and other radiation sources in space. The magnetosphere is not actually a sphere; it is shaped more like a teardrop, with a long "tail" extending away from the Sun

Several other planets, and even a few moons, in our Solar System also have magnetic fields. Our Moon has a very weak magnetic field, as does the planet Mars. Mercury's field is a bit stronger. The giant planets Jupiter and Saturn have extremely powerful fields. Uranus and Neptune also have fairly strong fields. We don't know about Pluto yet, but it is unlikely to have a strong field it has one at all. Venus does not have a magnetic field, probably because it rotates so slow Jupiter's moon Ganymede also has a magnetic field, and we have tentative hints that some other moons may have weak fields as well.

The Rocks

A rock can be defined as a solid substance that occurs naturally because of the effects of three basic geological processes: magma solidification; sedimentation of weathered rock debris and metamorphism. As a result of these processes, three main types of rock occur:

- **Igneous Rocks** (CSS 2009)- produced by solidification of molten magma from the mantle Magma that solidifies at the Earth's surface conceives **extrusive or volcanic** igneous rocks. When magma cools and solidifies beneath the surface of the Earth **intrusive** or **plutonic igneous** rocks are formed. The word igneous comes from the Latin word ignis meaning "fire." There are two types of igneous rocks: intrusive and extrusive. Intrusive igneous rocks form within Earth's crust: the molten material rises, filling any available crevices in the crust, and eventually hardens. These rocks are not visible until Earth above them has eroded away
- **Sedimentary Rocks** - formed by burial, compression, and chemical modification of deposited weathered rock debris or sediments at the Earth's surface. Sedimentary rocks are the only rocks in which fossils can be preserved. The elevated temperatures and pressures needed to form both igneous and metamorphic rocks destroy fossils and organic remnants. The presence of fossils and the types of fossil organisms in a rock provide clues about the environment and age of sedimentary rocks. For example, fish fossils in sedimentary rock indicate that the sediments that make up the rock were deposited in lake, river, or marine environment. By establishing the environment of the fossils in a rock, scientists learn more about the conditions under which the rock formed.

  Metamorphic Rocks -Metamorphic rock is rock that has changed from one type of rock into another. The word metamorphic comes from Greek and means "of changing form" Metamorphic rock is produced from igneous, sedimentary, or even other metamorphic

rocks. Most of Earth's crust is made up of metamorphic rock. Igneous and sedimentary rocks become metamorphic rock as a result of intense heat from magma and pressure from burial within Earth. Although the rock undergoes extreme heat and a great deal of pressure, it does not melt. If the rock melted, it would become igneous and not metamorphic rock. Instead, the heat and pressure combine to change the mineral makeup of the rock. Essentially, metamorphic rocks are made of the same minerals as the original rock, but the various minerals have been rearranged to make a new rock. There are two basic types of metamorphic rock: regional and thermal. **Regional metamorphic rock**, found mainly in mountainous regions, is formed by pressure. **Thermal metamorphic rock**, also called contact metamorphic rock, is formed by considerable pressure and, more important, intense heat.

Common Elements *found in the* Earth's Rocks

Element	Chemical Symbol	Percent Weight in Earth's Crust
Oxygen	O	46.60
Silicon	Si	27.72
Aluminum	Al	8.13
Iron	Fe	5.00
Calcium	Ca	3.63
Sodium	Na	2.83
Potassium	K	2.59
Magnesium	Mg	2.09

Examples of Igneous Rocks

Andesite is a gray to black volcanic rock. It is generally erupted from stratovolcanoes as
thick lava flows. It can also generate strong explosive eruptions to form pyroclastic flows.

- Andesites erupt at temperatures between 900 and 1100° C.
- Andesite contains crystals composed of plagioclase feldspar, pyroxenes, and hornblende.
- The word andesite comes from the Andes Mountain Range where andesite is common

Pumice is light and porous. It forms during explosive eruptions. Pumice is full of holes caused by expanding volcanic gases. It is composed of volcanic glass and minerals, and
can form in all types of magma: basalt, andesite, dacite, and rhyolite.

Examples of Sedimentary rocks

Limestone is made primarily of calcium carbonate or calcite. The most common source
of this calcite is the shells of marine organism

Breccia is made up of angular pebbles cemented together.

Sandstone is sand grains cemented together into solid stone

Examples of Metamorphic Rocks

Anthracite is a type of coal with a high carbon count, few impurities and with a high
luster (meaning it looks shiny).

Marble is a metamorphic rock that is formed from the sedimentary rock limestone.

Quartzite is a metamorphic rock that is formed from the sedimentary rock sandstone.

Slate is a metamorphic rock that is formed from the sedimentary rock mudstone.

Granulite is a metamorphic rock that is formed from the igneous rock basalt.

Minerals

(CSS 2002, 2009)

Minerals are the building blocks of all rocks. Presently there are about 4,000 minerals that have been identified. But what is a mineral besides a building block? A mineral is defined as a naturally occurring inorganic solid that has a definite chemical structure.

Minerals are made up of complex structures of elements. There are eight elements that make up most of these minerals; Oxygen, Silicon, aluminum, iron, calcium, sodium, potassium and magnesium; they account for about 98% of the earth's crust. From this point we have determined that elements are the building blocks of minerals and minerals are the building blocks of rocks.

The Physical Characteristics *of* Minerals

The physical characteristics of minerals include traits which are used to identify and describe mineral species. These traits include color, streak, luster, density, hardness, cleavage, fracture, tenacity, and crystal habit.

Certain wavelengths of light are reflected by the atoms of a mineral's crystal lattice while others are absorbed. Those wavelengths of light which are reflected are perceived by the viewer to possess the property of **color**. Some minerals derive their color from the presence of a particular element within the crystal lattice. The presence of such an element can determine which wavelengths of light are reflected and which are absorbed. This type of coloration in minerals is termed **idiochromatism**; different samples of an dichromatic mineral species will all display the same color. Other minerals are colored by the presence of certain elements in mixture. Different samples of such a species may exhibit a range of similar colors. Still other mineral species may usually be colorless, but may display several different and startling colors when trace amounts of impurities, or elements which are not an integral part of the crystalline lattice, are present. Coloration which is caused by the presence of an element foreign to the crystal lattice, whether in mixture or in trace amounts, is termed **allochromatism.** Certain elements are strong pigmenting agents and may lend vivid colors to specimens when they are present, whether as a part of the crystal lattice, in mixture, or as an impurity. These elements are termed the **chromospheres**.

Streak is the color which a mineral displays when it has been ground to a fine powder. Trace amounts of impurities do not tend to affect the streak of a mineral, so this characteristic is usually more predictable than **color**. Two different specimens of the same species may be expected to possess the same streak, whereas they may display different colors.

Minerals are either opaque or transparent. A thin section of an opaque mineral such as a metal will not transmit light, whereas a thin section of a transparent mineral will. Typically those minerals which possess metallic bonding are opaque whereas those where ionic bonding is prevalent are transparent. Relative differences in opacity and transparency are described as luster. The characteristic of luster provides a qualitative measure of the amount and quality of light which is reflected from a mineral's exterior surfaces. Luster thus describes how much the mineral's surface 'sparkles'.

The property of **density** is defined as mass per unit volume. Certain trends exist with respect to density which may sometimes aid in mineral identification. Native elements are relatively dense. Minerals whose chemical composition contains heavy metals, or those possessing an atomic number greater than iron (Fe, atomic number 26), are relatively dense. Species which form at high pressures deep within the earth's crust are in general more dense than minerals which form at lower pressures and shallower depths. Dark-colored minerals are typically fairly dense whereas light-colored ones tend to be less dense.

Hardness is defined as the level of difficulty with which a smooth surface of a mineral specimen may be scratched. Hardness has historically been measured according to the **Mohs** scale. Mohs' method relies upon a scratch test to relate the hardness of a mineral specimen to the hardness of one of a set of reference minerals. Hardness may also be measured according to the more quantitative but less accessible **diamond indentation method.**

Cleavage refers to the splitting of a crystal along a smooth plane. A cleavage plane is a plane of structural weakness along which a mineral is likely to split. The quality of a mineral's cleavage refers both to the ease with which the mineral cleaves and to the character of the exposed surface. Not every mineral exhibits cleavage.

Fracture takes place when a mineral sample is split in a direction which does not serve as a plane of perfect or distinct cleavage. A mineral fractures when it is broken or crushed. Fracture does not result in the emergence of clearly demarcated planar surfaces; minerals may fracture in any possible direction.

The characteristic of **tenacity** describes the physical behavior of a mineral under stress or deformation. Most minerals are brittle; metals, in contrast, are malleable, ductile, and sectile.

The term *crystal habit* describes the favored growth pattern of the crystals of a mineral species. The crystals of particular mineral species sometimes form very distinctive, characteristic shapes. Crystal habit is also greatly determined by the environmental conditions under which a crystal develops

Minerals *of* Pakistan

1	**Aluminum**	Khushab district, Kirthar Nits. Kalat, Ziarat and Loralai districts
2	**Iron Ore**	Kalabagh Mianwali district., Baluchistan
3	**Copper**	Saindak and Reko-diq in Baluchistan.
4	**Chromite Ore**	Dargai Jijal-Pattan and Chilas areas (Kohistan) Shunghail Muslim Bagh, Noshki, Ras-koh, Dilbadin, Miran shahWana,Khuzdar, Bela
5	**Zinc / Lead**	The Jurassic rocks of the Lasbela – Khuzdar Belt , Duddar Gunga
6	**Coal**	Salt Range and Markawal, Hangu , Cherat , Hamai, ,Duki ,Mach-Abegum Pir Ismail Ziarat Bar khan – Chamalang.
7	**Gypsum / Anhydrite**	Dadukhel, Rakhi-Munh, Khewra Safed koh-Rodo area. Suleman Range of D.G. Khan, D.I.Khan & Kohat district , Baluchistan.
8	**Phosphates**	Abbottoabad.
9	**Bauxite**	Hazara District
10	**Salt**	Salt Range (*160 kms in length, east and west trending mountainous arc between Rivers Jhelum and Indus*). Khewra, Warcha, Kalabagh, Bhadurkhel, Jatta and Karak Sal, Chakwal and Khushab
11	**Magnetite**	Kumhar in Abbottabad Lasbela and Khuzdar
12	**Limestone for lime**	Salt Range Potwar Plateau, Margalla Hills and Zinda Pir (Attock) Ganjo Takkar, Murli Hills, Mango Pir, Cape Monze, Kot Diji and Ranipir , Khyber Pakhtunkhwa and Northern Areas. Balochistan
13	**Kaolin (China Clay)**	Nagar Parkar, in Tharparkar District , Shah Dheri, Swat
14	**Natural Stones as Building Materials I).**	Dalbandin Hills Attock, Khyber Pakhtunkhwa and in Northern Areas, Chagai district.

	Granite(ii). Marble and Onyx	
15	**Gemstones**	Khyber Pakhtunkhwa, AJ&K and Northern Areas Chaga Panjgur; Kalat KillaAbdullah Khuzdar; Loralai
16	**Celestine**	Daud Khel, Thano BulaKhan.
17	**Natural oil**	Attock , Potwar, Jehlum, Khaskheli , Laghari , Tano Alam
18	**Natural Gas**	Uch near Multan.Adhi Rawalpindi district, Khairpur, Kandko Mari, Golarchi and Khaskheli, Pirkok, Sui,Mazarani,Golarchi,Sa
19	**Solar Salt**	Coastal areas of Karach
20	**Carbonate Soda:**	Nara Taluka of Khaipur State, in Nawabshah, Umerkot and Sha Bandar
21	**Soap Stone:**	Sherwan in Abbotabad district.

Pakistan Mineral Exports: Copper, Chromite, Zinc/Lead, Salt, Gypsum, Silica Sand, Flour Barite, Quartzite/ Quartz Powered etc

Gemstones

Humans have loved gemstones since very ancient times. They are supposed to have man mysterious properties like driving away demons and diseases, removing poisons and protectin one from the 'evil eye'. In Asia, nine kinds of gems are called precious stones, the rest are al semi-precious. A necklace called the navaratna made with all nine stones (ruby, pearl, cora emerald, yellow sapphire, diamond, blue sapphire, garnet and chrysoberyl) is considered ver auspicious and was often worn by kings and queens in India and South-East Asia.

The Colour of Gems

Most gems are minerals (pearls and corals are not). A mineral is a crystal made of th oxides of a metal. With the exception of diamonds (made of pure carbon), all other precio stones are generally oxides of aluminium, in which other things are present. For example, rubie are made of aluminium oxide and chromium. The aluminium oxide crystal gives the transluce shiny feel of the gem, while the chromium gives the red colour. Emeralds are made of berylliu aluminium silicate, with traces of chromium and vanadium, which give the green colour Hessonite is calcium aluminium silicate, while chrysoberyl is beryllium aluminium silicate.

The Mohs scale is used to sort the quality of gemstones, using their hardness. The scor depends on whether the stone can be scratched by something harder, and what stones it ca scratch. Nothing can scratch diamond, so it is the hardest with a score of 10. Talc is softest, with a score of just 1! Sapphires and rubies have a score of 9 (that is they can be scratched by diamond but nothing else), and emeralds have a scale of 8 (they can be scratched by diamonds and rubies)

Environmental Pollution (CSS 1988/2017)

Q: What are the factors responsible for environmental pollution? (CSS-2017)

Pollution is defined as an 'undesirable change in the physical, chemical or biological characteristics of air, water and land brought about by man's activities that may harmfully affect living organisms and other resources'.

Organization for Economic Cooperation and Development (OECD), October 2013's report says pollution will become biggest cause of premature death, killing an estimated 3.6 million people a year by 2050. Urban air pollution is set to become the biggest environmental cause of premature death in the coming decades, overtaking even such mass killers as poor sanitation and a lack of clean drinking water, according to a new report.Both developed and developing countries will be hit, and by 2050, there could be 3.6 million premature deaths a year from exposure to particulate matter. But rich countries will suffer worst effects from exposure to ground-level ozone, because of their ageing populations – older people are more susceptible.The warning comes in a new report of OECD, which is a study of the global environmental outlook until 2050. The report found four key areas that are of most concern - climate change, loss of biodiversity, water and the health impacts of pollution. If current policies are allowed to carry on, the world will far exceed the levels of greenhouse gas emissions that scientists say are safe, the report found.

Causes of Pollution

The ultimate cause of pollution is human activity itself. Pollution is a human contribution to nature. Science has evolved technologies and technologies have helped the human welfare. In the process, the pollution has been a part of technology and therefore a part of human miseries.

Human activities mainly include:

- Industries for various human needs - directly and indirectly
- Agriculture for food production and industrial needs
- Health care for health of human beings and animals
- Transport for mobility of human beings
- Dwelling for settlement in city or villages
- Energy for various direct human needs and industrial needs.

Main causes of environmental pollution

1-Automotive industry

In every city, especially the cosmopolitan ones, vehicles of daily use produce different types of gases harmful to health and the environment, such as:

- Carbon dioxide.
- Carbon monoxide.
- Nitrous oxide.
- Sulfur dioxide.
- Hydrogen sulfide.

These gases and particles contribute to air pollution.

Vehicle transportation is essential in the daily life of people, and necessary because of current economic and industrial movements.

Even so, measures can be taken to reduce the impact of pollution, such as using bicycles to travel short distances or using public transport.

The idea of the use of electric cars for the future, free of pollutant emissions for the environment, has now come into force.

2-Proliferation of plastic

The creation of plastic has its origins in 1907 in New York. Since then, it has been part of a countless number of products on the market.

The main problem with plastic is that it takes many years to decompose (on average, five hundred years).

Added to that, its low cost of production, so its proliferation is inevitable. Then, a serious problem arises in the long term.

Burying plastic is not the best option, as it is not a biodegradable material. Of course, the idea that the ocean can swallow it is also ruled out.

Then, the best option to avoid the accumulation over the centuries of this synthetic material would be the burning of it.

Burning the plastic would help free the earth and oceans from having to take over tons of this material, but in turn, would be contributing again to the first item in the listing, which is the emission of toxic gases.

Keeping in mind that virtually every element of everyday use is made of plastic due to the low cost of manufacturing, it is a very difficult problem to solve.

3-Annoying Noises

Sound pollution (or noise pollution) is not a minor issue. Noise, unlike the two previous cases and most forms of pollution, is not something that prevails in time and presents a problem by accumulation. However, it has other ways of affecting the environment.

Excessive sound disturbs normal living conditions in a particular area, and this has consequences, especially in terms of health, both for animals and for humans.

Animals that have the most acute auditory sense, depend almost 100% of this to locate their prey and communicate. An alteration of the sonic waves is a total confusion for them, and interrupts their normal habits of life.

In both cases (animals and humans), excessive noise not only affects the hearing ability, but also causes other health damages (physical and psychological damage).

Again, urban areas and cosmopolitan cities are the areas most affected by noise pollution, transport, together with any machine that uses an exploding engine (for example, lawn mowers) play an important role in this type of pollution.

4-Water dumpsters

Unlike the items listed above, the water contamination can occur both naturally and by acts of man, although the latter has greater responsibility for it.

Water pollution from natural sources may be due to:

- Climatic factors.
- Geological factors.
- Saline intrusion.
- Ashes of a volcano.
- Etc.

However, these natural causes do not pose a greater danger and imbalance on a global scale.

AND As far as man is concerned, the causes are practically innumerable, the ocean has become a dump of all kinds since industrialization, added to the water that flows into rivers and seas from urban areas and chemical and radioactive waste from factories.

Water pollution affects not only the aquatic ecosystem, but all living beings on the planet.

5-Electronic scrap

The main problems that the technological industry presents to the environment are two:

- The shelf life of manufactured products is relatively short.
- This has accelerated growth and must be constantly innovated to not be out of the market. since products are generally obsolete and discarded, regardless of whether they work or not.

Thus, like plastic, electronic scrap accumulates day by day massively on planet earth, in addition to electronic devices have harmful materials for health and the environment, such as lead and mercury.

6-Deforestation

Deforestation is 100% man-made. The indiscriminate cutting of trees for economic purposes seems to have no limits.

Some consequences of deforestation:

- **Floods**: trees absorb large amounts of water, thus avoiding overflows of rivers and watersheds.
- **Destruction of biodiversity**: many species of plants and animals are in danger of extinction due to the alteration of their natural habitat.
- **Climate change**: Trees absorb the greenhouse gases that cause global warming . in addition to blocking the rays of the sun at daytime.

While wood is a necessary resource in everyday life, in order to avoid problems in the future, replanting should be a legal obligation every time a tree is cut.

7-Laws and education

The laws governing massive polluters (factories) have not been enough to curb the devastation of the environment and the natural destruction of particular areas of planet earth.

On the education side, just the last two decades began to take action on the issue accordingly.

A person in many cases contaminates without having a minimum awareness of the grain of sand that is contributing to the global damage of the planet.

Laws and education have a profound impact on this cause.

Air Pollution

The release of poisonous gases like CO, N_2O and gases from industries and automobiles has disturbed the balance among the air components affecting both the living and a non-living components of earth. *Air pollution may be defined in the following ways.*

- Any atmospheric condition in which certain substances are present in such concentrations that they can produce undesirable effects on man and his environment.
- Air pollution is the excessive concentration of foreign matter in the air which adversely affects the wellbeing of individuals or causes damage to property.

Sources of Air Pollution

Human activities are the main sources of air pollution. Using energy in our homes, industrial activities, transport and farming are the main actions that have been directly linked to emissions.

1. **Traffic pollutants**: Gases and particles released from cars and other vehicles include a complex mixture of many pollutants. The erosion of material on the roads and the wear of tyres and brakes can also produce pollutants.

2. **Stationary combustion sources**: The burning of fossil fuels, such as coal and oil at both power plants and in the home, is also a major source of air pollution.
3. **Other sources**: Forest fires and the burning of living, or recently living organisms (biomass), represent a further major source of emissions.
4. **Sulphur oxides** (SOx)/sulphur dioxide (SO2) (*From burning coal and oil*)
5. **Nitrogen oxides** (NOx) /nitrogen dioxide (NO2) (*From burning fuel in cars and other industrial processes*)
6. **Carbon monoxide** (CO) (*From combustion processes low in oxygen, burning wood coal, fuel (also from cars)*)
7. **Carbon dioxide** (CO2) (*From volcanic activity and hot springs, combustion processes, cars, and power plants*)
8. **Volatile organic compound** (*Evaporates from sources such as vehicle exhausts, cleaning agents, furniture polish and fabric softeners*)
9. **Ammonia** (*Used to fertilise crops and emitted from this agricultural process and farm animals*)
10. **Persistent organic pollutants** (POPs) (*Produced through industrial processes and waste*
11. *Incineration*)
12. **Particulate matter** (from sulphates and nitrates) (*Fine particles which are either man made or natural*)

A number of processes that contribute to air pollution, such as burning fossil fuels, also contribute to an excess amount of greenhouse gases in the environment, which leads to global warming.

Effects of Air Pollution

1. **Respiratory and heart problems:** The effects of Air pollution are alarming. They are known to create several respiratory and heart conditions along with Cancer, among other threats to the body. Several millions are known to have died due to direct or indirect effects of Air pollution. Children in areas exposed to air pollutants are said to commonly suffer from pneumonia and asthma.
2. **Global warming:** Another direct effect is the immediate alterations that the world is witnessing due to Global warming. With increased temperatures world wide, increase in sea levels and melting of ice from colder regions and icebergs, displacement and loss of habitat have already signaled an impending disaster if actions for preservation and normalization aren't undertaken soon.
3. **Acid Rain:** Harmful gases like nitrogen oxides and sulfur oxides are released into the atmosphere during the burning of fossil fuels. When it rains, the water droplets combines with these air pollutants, becomes acidic and then falls on the ground in the form of acid rain. Acid rain can cause great damage to human, animals and crops.
4. **Eutrophication:** Eutrophication is a condition where high amount of nitrogen present in some pollutants gets developed on sea's surface and turns itself into algae and adversely affects fish, plants and animal species. The green colored alga that is present on lakes and ponds is due to presence of this chemical only.
5. **Effect on Wildlife:** The toxic pollutants deposit over the surface of the water and can also affect sea animals.
6. **Depletion of Ozone layer:** Ozone exists in earth's stratosphere and is responsible for protecting humans from harmful ultraviolet (UV) rays. Earth's ozone layer is depleting due to the presence of chlorofluorocarbons, hydro chlorofluorocarbons in the atmosphere. As ozone layer will go thin, it will emit harmful rays back on earth and can cause skin and eye related problems. UV rays also have the capability to affect crops.

Control of Air Pollution

1. **Use public mode of transportation:** Encourage people to use more and more public modes of transportation to reduce pollution.
2. **Conserve energy:** Switch off fans and lights when you are going out. Large amount of fossil fuels are burnt to produce electricity.
3. **Understand the concept of Reduce, Reuse and Recycle:** Do not throw away items that are of no use to you. In-fact reuses them for some other purpose.
4. **Emphasis on clean energy resources:** Clean energy technologies like solar, wind and geothermal are on high these days. Governments of various countries have been providing grants to consumers who are interested in installing solar panels for their home. This will go a long way to curb air pollution.
5. **Use energy efficient devices:** CFL lights consume less electricity as against their counterparts. They live longer, consume less electricity, lower electricity bills and also help you to reduce pollution by consuming less energy.

Air Pollution in Pakistan

Air pollution is an emerging environmental issue in major cities of Pakistan. It is primarily considered as an urban problem in Pakistan. Dust and smoke particles in Pakistan are generally twice the world average and five times higher than the developed world. Therefore increasing rate of Air Pollution in Pakistan is significantly high. Though some pollution comes from the natural sources, but most pollution is the result of human activities.

Rapid urbanization and industrial growth in the country is also altering the quality of air in major cities, largely due to emissions from power plants, industries and vehicles especially from those having poor efficiency and mechanical condition. Air pollution is costing the Pakistan 1 per cent of total GDP in the form of respiratory health problems and premature deaths. The level of air pollution in Pakistan's two largest cities, Karachi and Lahore, is estimated to be 20 times higher than World Health Organization standards, and continuing to rise. Islamabad, the capital, is perpetually smothered by a thick cloud of smog that hides views of the Margalla Hills that tower over the city's tree-lined streets.

The biggest causes are the operations of fossil fuel-burning power plants and automobiles that combust fuel. Combined these two sources are responsible for about 90% of all air pollution. Most serious issue of air pollution in Pakistan is the presence of excessive suspended particulates matter (SPM). The major sources of SPM are vehicles, industry, burning of solid waste, bricks kilns and natural dust. Everyday each person inhales 20,000 liters of air. Every breath, we risk hailing dangerous chemicals that have found their way into the air. One of the important factors for producing pollution is increasing rate of urbanization. Due to people migration to cities, growth of infrastructure in cities together with growth in road transport that ultimately cause pollution in the air. Transportation vehicles are also important agents which contribute in air pollution. The road vehicles emit different gases such as sulphur-dioxide (SO2). Lead Oxide (LO2).These gases when accumulated in the atmosphere than the air become polluted. Increase in transportation also generates dust particles in the atmosphere and polluted the air. Cities with large number of automobiles or those that use great quantities of coal often suffer most severely from the problem of air pollution.

Burning garbage is another factor which releases dangerous gases and dust which contribute to global warming and pollute lakes, forests, oceans and cities. Recycling has increased in these days. It goes into dumpsites which in turn pollute the water supply, land and air. Pakistan being one of the largest coal deposit in the world consisting of 184.123 billion tons can produce 1000, 000MW electricity for next three hundred years. Coal mining produces methane, a potent greenhouse gas. According to inter-government Panel on climate change, methane as a global warning potential 21 times greater than that of carbon dioxide on a 100 year life time. While burning coal in power plants is most harmful to air quality due to emission of dangerous gases, the process of mining can release packets of hazardous gases. Although Pakistan is not utilizing its coal resources with full but still it can be the major contributor of air pollution.

Air Pollution in Pakistan is one of the worst factors that are disturbing our environment. Due to deforestation, lack of proper environmental protection policies, uncontrolled increase in industrial pollution, use of coal etc and based on the indicators of air pollution, it can be very safely said that the rate of air pollution in Pakistan is very high.

Smog

***Q:* Write a comprehensive note on 'Smog'** (CSS-2018)

Smog is air pollution that reduces visibility. The term "smog" was first used in the early 1900s to describe a mix of smoke and fog. The smoke usually came from burning coal. Smog was common in industrial areas, and remains a familiar sight in cities today.

Today, most of the smog we see is photochemical smog. Photochemical smog is produced when sunlight reacts with nitrogen oxides and at least one volatile organic compound (VOC) in the atmosphere. Nitrogen oxides come from car exhaust, coal power plants, and factory emissions. VOCs are released from gasoline, paints, and many cleaning solvents. When sunlight hits these chemicals, they form airborne particles and ground-level ozone—or smog.

Ozone can be helpful or harmful. The ozone layer high up in the atmosphere protects us from the sun's dangerous ultraviolet radiation. But when ozone is close to the ground, it is bad for human health. Ozone can damage lung tissue, and it is especially dangerous to people with respiratory illnesses like asthma. Ozone can also cause itchy, burning eyes.

Classic smog results from large amounts of coal burning in an area and is caused by a mixture of smoke and sulfur dioxide.

In the 1950s a new type of smog, known as Photochemical Smog, was first described.

Causes of smog

Smog is caused as a result of industrial activities, vehicular traffic, open burning, incinerators, higher temperature, geography of a place, sunlight and calmer winds. These factors contribute to an all-encompassing smog, which can remain trapped in the atmosphere with higher temperature and sunlight.

However, it must be noted that smog is caused in a location that is far from the source of pollution. This is because the process that leads to smog occurs after the hazardous particles have been drifted away by the wind.

Effects of smog

Exposure to smog can be severely harmful for the health of the exposed as it can cause/aggravate health conditions such as follows:

- **Chest infections/Irritation:** When you inhale ground-level ozone, it can affect your respiratory system in an adverse way, leading to coughing and irritation. When you are exposed to it for longer durations, it can even lead to lung infections.

- **Worsening of asthma/bronchitis/emphysema:** Patients of such respiratory problems have the worst of times when smog hits such high levels. Patients can have frequent and severe asthma attacks. In extreme cases, the risk of developing these diseases may also significantly shoot up.
- **Cold and eye irritation:** Smog significantly reduces one's immunity to cold and can cause irritation in the eyes.
- **Premature mortality:** Ground-level ozone and PM 2.5 are direct contributors to an increased risk of premature mortality.
- **Damage to crops:** Besides impacting humans negatively, smog can also inhibit plant growth and cause damage to forests and crops.

Who is at a greater risk?

- Smog affects everyone differently, depending on their lifestyle, health condition and age.
- The groups which are the most susceptible are:
- **Children:** As children spend a lot of time outdoors, they are more prone to getting affected by smog. Also, their risk of developing asthma is quite high as it is the most common respiratory ailment among children.
- **People with respiratory disorders**: If someone already has respiratory problems like asthma, severe bronchitis or emphysema, they will experience a worsening of symptoms when exposed to smog as they are more vulnerable to the effects of ground-level ozone.

Water Pollution

(CSS 1995, 2000, 2001, 2005, 2018)

***Q:* What is 'Water Pollution*. Discuss its causes and measurement methods. Name the countries with the highest and lowest percentage of it** (CSS-2018)

Water Pollution, contamination of streams, lakes, underground water, bays, or oceans by substances harmful to living things. Water is necessary to life on earth. All organisms contain it; some live in it; some drink it. Plants and animals require water that is moderately pure, and they cannot survive if their water is loaded with toxic chemicals or harmful microorganisms. If severe, water pollution can kill large numbers of fish, birds, and other animals, in some cases killing all members of a species in an affected area. Pollution makes streams, lakes, and coastal waters unpleasant to look at, to smell, and to swim in.

Major Types of Water Pollution

The major water pollutants are chemical, biological, or physical materials that degrade water quality. Pollutants can be classed into eight categories, each of which presents its own set of hazards.

Petroleum Products

Oil and chemicals derived from oil are used for fuel, lubrication, plastics manufacturing, and many other purposes. These petroleum products get into water mainly by means of accidental spills from ships, tanker trucks, pipelines, and leaky underground storage tanks. Many petroleum products are poisonous if ingested by animals, and spilled oil damages the feathers of birds or the fur of animals, often causing death. In addition, spilled oil may be contaminated with other harmful substances, such as polychlorinated biphenyls (PCBs).

Pesticides and Herbicides

Chemicals used to kill unwanted animals and plants, for instance on farms or in suburban yards, may be collected by rainwater runoff and carried into streams, especially if these substances are applied too lavishly. Some of these chemicals are biodegradable and quickly decay into harmless or less harmful forms, while others are no biodegradable and remain dangerous for a long time.

Heavy Metals

Heavy metals, such as copper, lead, mercury, and selenium, get into water from many sources, including industries, automobile exhaust, mines, and even natural soil. Like pesticides heavy metals become more concentrated as animals feed on plants and are consumed in turn by other animals. When they reach high levels in the body, heavy metals can be immediately poisonous, or can result in long-term health problems similar to those caused by pesticides and herbicides. For example, cadmium in fertilizer derived from sewage sludge can be absorbed by crops. If these crops are eaten by humans in sufficient amounts, the metal can cause diarrhea and over time, liver and kidney damage.

Sewage

Untreated or inadequately treated municipal sewage is a major source of groundwater and surface water pollution in the developing countries. The organic material that is discharged with municipal waste into the watercourses uses substantial oxygen for biological degradation thereby upsetting the ecological balance of rivers and lakes. Sewage also carries microbial pathogens that are the cause of the spread of disease.

Excess Organic Matter

Fertilizers and other nutrients used to promote plant growth on farms and in gardens may find their way into water. At first, these nutrients encourage the growth of plants and algae in water. However, when the plant matter and algae die and settle underwater, microorganisms decompose them. In the process of decomposition, these microorganisms consume oxygen that is dissolved in the water. Oxygen levels in the water may drop to such dangerously low levels that oxygen-dependent animals in the water, such as fish, die. This process of depleting oxygen to deadly levels is called eutrophication

Effects of Water Pollution

Water pollution has number of effects. The effects could be classified as

- Effects on Ecosystem
- Effects on Animal Health
- Effects on Human Health

Effects on Ecosystem

1. Besides inorganic nutrient input, with the inflow of waste water, decomposition of organic wastes, plant nutrients such as nitrates and phosphates takes place. This promotes the growth of oxygen consuming algae (algal bloom), especially the blue-green algae The growth of oxygen consuming algae, which deoxygenates water killing fish and other animals is referred to as eutrophication.
2. Shifts in biodiversity of animals and plants in polluted ecosystem.
3. Imbalance in host - parasite relations in the ecosystem and changes in food - webs and food chains.
4. Imbalances in microbial population and effects due to such imbalances.
5. Depositions of deleterious chemicals in soil leading to loss of soil fertility.

Effects on Animal Health

1. Large scale death of aquatic and terrestrial animals
2. Reduced reproduction rate

3 Increased incidence of diseases
4. Imbalances created in secondary food chains
5. Accumulation of bioaccumulative and non-biodegradable pollutants in animal bodies.
6 Some organochlorine pesticides (like DDT, BHC, Endrin) are known for bioaccumulative and biomagnifiable characters.

Effects on Human Health

1. Increased incidence of tumours, ulcers due to nitrate pollution.
2. Increased incidence of skin disorders due to contact with pollutants.
3. Increased incidence of constipation, diarrhea and infections to intestine.
4. Dangerous effects on growing foetus in pregnant women.
5. Concentration of pollutants due to bioaccumulative pesticides.through secondary and tertiary food chain in case of non - vegetarians.
6. Still births, abortions and birth of deformed children.
7. 'Blue baby' disease caused by methane globinemia - which results in asphyxia (reduced O_2 supply).
8. Reduced activity of immune system.
9. Loss of memory power and reduced mental sharpness.
10. Water borne diseases like jaundice, hepatitis, and gasteroenteritis will be more prevalent due to water pollution.
11. Reduced bone development and muscular development.
12. Reduced male fertility.
13. Shifts in physiological cycles of human body.

Water Pollution Control Criteria

Basic freedom from pollution. To the extent practical and possible, all bodies of water should attain the basic criteria of the "Five Freedoms from Pollution":

1. Free from suspended solids or other substances that enter the waters as a result of human activity and that will settle to form putrid or otherwise objectionable sludge deposits, or that will adversely affect aquatic life
2. Free from floating debris, oil, scum and other floating materials entering the waters as a result of human activity in amounts sufficient to be unsightly or cause degradation
3. Free from materials entering the waters as a result of human activity, producing colour, odour or other conditions in such degree as to create a nuisance
4. Free from substances entering the waters as a result of human activity, in concentrations that are toxic or harmful to human, animal or aquatic life and/or are rapidly lethal in the mixing zone
5. Free from nutrients entering the waters as a result of human activity, in concentrations that create nuisance growths of aquatic weeds and algae.

Water Pollution in Pakistan

There are many sources of water pollution in Pakistan. Most of them are found in Karachi as it is an area of industries. Although it is a government policy to filter the industrial water and then release it into the sea many industries here are dumping contaminated water in seas thereby increasing the threat of extinction of marine life as well as polluting the water.

According to the Climate Change Vulnerability Index Pakistan is considered as a high risk country Around 62 percent of Pakistan's urban and 84 percent of its rural population do not treat their water, resulting in 100 million cases of diarrheal diseases registered in hospitals, with

40 percent of deaths attributed to drinking polluted water.

Unsafe drinking water is a source of many diseases including diarrhoea, typhoid intestinal worms and hepatitis and an estimated 250.000 child deaths occur each year in Pakistan due to water-borne diseases. It is estimated that more than 1.6 million DALYs (Disability Adjusted Life Years) are lost annually as a result of death and ailment due to diarrhoea and almost 90,000 as a result of typhoid.

Inadequate quantity and quality of potable water and poor sanitation facilities are associated with a host of illnesses and a study conducted by UNICEF found that 20-40 percent of the hospital beds in Pakistan are occupied by patients suffering from water-related diseases.

Countries that are the Greatest Water Polluters

Country		Daily Amount of Water Pollutants (kg)
1.	China	6,088,660
2.	United States	1,968,200
3.	India	1,556,370
4.	Japan	1,279,290
5.	Germany	1,020,140
6.	Indonesia	753,657
7.	Brazil	629,406
8.	United Kingdom	604,821
9.	Italy	495,973

Montreal Protocol

Montreal Protocol on Substances that deplete the Ozone layer is an international treaty designed to protect the ozone layer by phasing out the production and consumption of a number of substances believed to be responsible for ozone depletion, and called Ozone Depleting Substances (ODS). The treaty was opened for signature on September 16, 1987 and entered into force on January 1, 1989.

Introduction to the Montreal Protocol

The Montreal Protocol is widely considered as the most successful environment protection agreement. The Protocol sets out a mandatory timetable for the phase out of ozone depleting substances. This timetable has been reviewed regularly, with phase out dates accelerated in accordance with scientific understanding and technological advances.

The Montreal Protocol sets binding progressive phase out obligations for developed and developing countries for all the major ozone depleting substances, including CFCs, halons and less damaging transitional chemicals such as HCFCs.

The Multilateral Fund, the first financial mechanism to be created under an international treaty, was created under the Protocol in 1990 to provide financial assistance to developing countries to help them achieve their phase out obligations.

The Montreal Protocol targets 96 chemicals in thousands of applications across more than 240 industrial sectors. The Multilateral Fund has provided more than US $2.5 billion in financial assistance to developing countries to phase out production and consumption of ozone depleting substances since the Protocol's inception in 1987.

The Protocol has been further strengthened through five Amendments — London 1990, Copenhagen 1992, Vienna 1995, Montreal 1997 and Beijing 1999 — which have brought forward phase out schedules and added new ozone depleting substances to the list of substances controlled under the Montreal Protocol.

The Montreal Protocol has also produced other significant environmental benefits. Most notably, the phase out of ozone depleting substances is responsible for delaying climate forcing by up to 12 years.

Universal ratification of the Montreal Protocol on Substances that Deplete the Ozone Layer

Damage to the Earth's protective ozone layer has sparked unprecedented worldwide concern and action. Since it was agreed internationally in 1987 to phase out ozone depleting substances (also known as ODS), 196 countries have ratified the Montreal Protocol. In September 2009, East Timor ratified the Montreal Protocol, making it the first international environmental treaty to achieve complete ratification — a truly remarkable effort that reflects the universal acceptance and success of the agreement.

Pakistan and Montreal Protocol

Pakistan ratified the Vienna Convention, Montreal Protocol in 1992. Commonly used ODSs in Pakistan were chlorofluorocarbons (CFCs). Halons, carbon tetrachloride (CTC) and Methyl Bromide. These ODSs were mainly used in the manufacturing of deep-freezers, refrigerators, foam blowing, fire extinguisher, process agents and solvents etc. Pakistan has successfully phased out the 1st Generation of ODSs and is now working on phase out of 2nd Generation of ODSs. In this regard 10% reduction target of 2nd generation of ODSs i.e. Hydrochlorofluorocarbons (HCFC) has been achieved by 1st January, 2015.

Keeping in view Pakistan's commitments to the international community, an National Ozone Unit (NOU) under the project entitled "Institutional Strengthening of Ozone Cell for the Implementation of the Montreal Protocol" with the financial assistance of Multilateral Fund of the Montreal Protocol has been established under the Ministry of Climate Change, Government of Pakistan since January 1996.

Objectives of the National Ozone Unit

The National Ozone Unit is following up and implementing all related activities such as legislative/regulatory measures, data reporting, mass awareness, implementation of HPMP, promotion of alternatives to CFC-based Metered Dose Inhalers and the accelerated phase out of the HCFCs etc. This project assists the Government of Pakistan to achieve its long-term goals to implement various ODSs phase out management plan (HPMP).

The NOU besides fulfilling the international commitments of Govt of Pakistan, aims to assist local industry in the preparation of phase out sub-projects; and disseminating information on ODSs free technologies and phase out activities. It also oversees and monitor import & usage of ODSs as well as implementation of phase out projects. The NOU is held responsible to establish and maintain data base regarding demand and supply of ODSs in the country.
NOU plays a critical role to formulate and enact policies and legislation for the phasing out of

HCFCs in the country. NOU is facilitating the all local HCFC based industry for conversion of technology into ozone friendly technology.

Kyoto Protocol

The Kyoto Protocol, an agreement reached in Kyoto, Japan, in 1997, mandating that industrialized nations cut their greenhouse gas emissions.

The Kyoto Protocol was an amendment to the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty intended to bring countries together to reduce global warming and to cope with the effects of temperature increases that are unavoidable after

150 years of industrialization. The provisions of the Kyoto Protocol were legally binding on the ratifying nations and stronger than those of the UNFCCC.

Countries that ratify the Kyoto Protocol agreed to reduce emissions of six greenhouse gases that contribute to global warming: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, HFCs, and PFCs. The countries were allowed to use emissions trading to meet their obligations if they maintained or increased their greenhouse gas emissions. Emissions trading allowed nations that can easily meet their targets to sell credits to those that cannot.

Facts:

192 parties have ratified the protocol (191 states and one regional economic integration organization). The United States has not; it dropped out in 2001.

The protocol mandated that 37 industrialized nations plus the European Community cut their greenhouse gas emissions. Developing nations were asked to voluntarily comply.

More than 100 developing countries, including China and India, were exempted from the treaty.

The treaty could not go into effect until at least 55 countries, accounting for 55% of the world's emissions in 1990, ratified it.

The signatories agreed to cut their country's emissions to 5% below 1990 levels between 2008 and 2012.

The treaty also established an international trading system, which allows countries to earn credits toward their emission target by investing in emission cleanups outside their own country. According to the Global Carbon Atlas, the largest contributors of greenhouse gases in 2014 were China and the United States.

Timeline:

- **December 1-11, 1997** - The Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) is held in Kyoto, Japan. More than 150 nations attend and adopt the first international treaty on controlling and reducing greenhouse gases.
- **November 2, 1998** - In Buenos Aires, Argentina, 160 nations meet to work out details of the protocol and create the "Buenos Aires Action Plan."
- **July 23, 2001** - Negotiators from 178 countries meet in Bonn, Germany, and agree to adopt the protocol. The United States doesn't participate.
- **November 10, 2001** - Representatives from 160 countries meet in Marrakech, Morocco, to further work out details of the protocol.
- **November 18, 2004** - The Russian Federation ratifies the protocol, giving new hope that it can be implemented, even without the United States.
- **February 16, 2005** - The Kyoto Protocol takes effect.
- **December 12, 2011** - Canada officially renounces the Kyoto Protocol. Environment Minister Peter Kent says Kyoto's goals are unworkable because the United States and China never agreed to Kyoto, and that a new pact is needed to address emissions.
- **December 2012** - The Kyoto Protocol is extended to 2020 during a conference in Doha, Qatar.
- **June 23, 2013** - Afghanistan adopts the Kyoto Protocol, becoming the 192nd participant.
- **2015** - At the COP21 sustainable development summit, held in Paris, all UNFCCC participants sign the "Paris Agreement" effectively replacing the Kyoto Protocol. The parties agree to limit warming "well below" 2 degrees, and below 1.5 degrees above pre-industrial levels if feasible.

Background

The Kyoto Protocol was negotiated in Kyoto, Japan, in December 1997. It was opened for signature on March 16, 1998, and closed a year later. Under terms of the agreement, the Kyoto Protocol would not take effect until 90 days after it was ratified by at least 55 countries involved in the UNFCCC. Another condition was that ratifying countries had to represent at least 55 percent of the world's total carbon dioxide emissions for 1990.

The first condition was met on May 23, 2002, when Iceland became the 55th country to ratify the Kyoto Protocol. When Russia ratified the agreement in November 2004, the second condition was satisfied, and the Kyoto Protocol entered into force on February 16, 2005.

What was the actual agreement that came out of Kyoto?

A treaty that committed 37 industrialized nations plus the European Community to cut their emissions of six greenhouse gases by an average of 5 percent by 2012, compared with 1990 levels.

The six gases targeted for reduction included carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (used in air conditioning), perfluorocarbons (often produced by aluminum production) and sulfur hexafluoride (used in the electrical industry). Carbon dioxide was the gas that policymakers were most concerned about.

Within the average of 5 percent, different countries had different targets. The 15 countries in the European Union at the time, as well as some eastern European countries and Switzerland, had targets of 8 percent below 1990 levels. The United States committed to a 7 percent reduction and Japan, along with Canada, Hungary, and Poland, agreed to a 6 percent cut.

But because the premise of the agreement was that industrially developed countries were historically responsible for the rise in global greenhouse gas emissions since the 1800s, and produced the majority of the world's emissions in 1997, these binding targets covered only developed countries. Emerging economies like China and India were exempted from setting numerical targets and promised only to do their best to reduce emissions.

What was the result?

Before the meeting in Kyoto, the U.S. Congress warned that unless a deal was struck that forced obligations on developing nations like China and India, America would not ratify the Kyoto Protocol. Barely had the agreement been reached when U.S. congressional representatives in Kyoto who had opposed it said it would never fly. Pressure from the U.S. gas and oil lobbies to scuttle the deal had been strong prior to the deal, and after George W. Bush became president in 2001 he announced that America was pulling out.

For the other nations, the Kyoto Protocol took effect in February 2005. Attempts to work out another deal that would include developing nations continued to create tensions, especially between the U.S. and a rapidly growing China.

When the Kyoto Protocol's first stage came to an end in 2012, it was agreed in Doha to extend the period to 2020. However, as of last month, only 88 of the original Kyoto Protocol signatories had accepted the Doha Amendment, which would have kept their reduction goals under the Kyoto Protocol in place until 2020.

At least 144 Kyoto Protocol countries are needed for the amendment to go into force.

What's the connection between the 2015 Paris climate agreement and the Kyoto Protocol?

After years of failure to reach an international consensus on a plan of action to replace the Kyoto pact, U.N. negotiators agreed in Paris two years ago that all nations would work to keep the global temperature rise this century "well below" 2 degrees Celsius above pre-indus levels and to make serious efforts to keep the rise at just 1.5 degrees.

More financing was promised for developing countries in particular to reduce emissi and new structures for reporting national greenhouse gas emissions and mitigation policies w agreed upon.

However, President Donald Trump withdrew his country from the Paris agreeme which has since been ratified by 170 countries, including all of the major developed and emerg economies, leaving the U.S. as the sole major polluter to opt out.

What is the legacy of the Kyoto Protocol?

Politically, opinion is divided. The United Nations calculates that even without U participation, total emissions by advanced countries had dropped 22.6 percent compared w 1990 levels by 2012, the end of the first pact's period.

U.N. Climate Secretary Patricia Espinosa credits the Kyoto Protocol for inspir innovation and increased use of renewable energy, and energy efficiency in particular, over t past two decades. Others note the general rise in public awareness of the environmental problem caused by climate change, and efforts to live more environment-friendly lifestyles, following th adoption of the Kyoto Protocol.

On the other hand, critics of the climate pact say its failure to include countries like Chin and India means that attaining the temperature goal set in Paris for this century is all the mor harder to reach.

In a message to the U.N.'s annual climate change conference in Bonn last month, U.N Secretary-General Antonio Guterres said the world was not yet on track to meet this goal.

Pakistan and Kyoto Protocol

Pakistan, is basically a developing country with very low Greenhouse gases emission ratio of 0.3% to 0.4% compared to other countries and hence there is no strict binding on Pakistan to reduce its Greenhouse gases emissions but still the government is pursuing an agenda to reduc emissions for the benefit of its own people. One important sector that should be emphasized is the alternative energy sector because of the ongoing energy crisis in the country.

However, the government is still facing problems in taking some concrete steps becaus of the following reasons.

I. Lack of Public awareness is one of the reasons that is hampering all the steps. The common man has no experience of using renewable energy causing hindrance in its use

II. Lack of investment is another reason which has proved fatal for all policies implemented for this purpose. The government doesn't have resources that can start alternative energy projects which tend to be relatively costly.

III. Lack of institutional infrastructure is another highlighting point which hasn't allowe proper implementation of this policy.

Apart from these, some other factors have also proved as drawbacks which include, n subsidy from the government, lack of incentives for investors, lack of skills on both the top and bottom layer and lack of proper rules to prove vital for investment in projects pertaining t reductions in emissions reductions.

Land Pollution

Pollution, in simple terms, can be defined as contamination of the environment, bringing about adverse changes and effects to the ecosystem.

In a similar manner, when a piece of land gets polluted due to various factors, it causes harm to the biodiversity and mankind, which is called land pollution.

Pollution includes visible litter and waste along with the soil itself being polluted. The soil gets polluted by the chemicals in pesticides and herbicides used for agricultural purposes along with waste matter being littered in urban areas such as roads, parks, and streets.

Land Pollution has come to become one of the serious concerns that we collectively battle. Land pollution, in other words, means degradation or destruction of earth's surface and soil, directly or indirectly as a result of human activities. The degradation of land that could be used constructively in other words is land pollution.

Causes of Land Pollution

Below are the sources of land pollution:

1. Landfills

Landfills are sites designated for dumping rubbish, garbage, or other sorts of solid wastes. Historically, they are the most common means of disposing solid waste which is either buried or left to pile in heaps. Landfill is a common phenomenon around the world, especially due to the increased number of wastes from our homes, schools, offices, hospitals, and markets. Some landfills are well managed and designed as part of integrated waste management.

However, most communities leave the landfills unattended to which cause land pollution and uncontrolled buildup of all sorts of solid waste materials. Here are the causes, effects, and solutions to landfills

2. Deforestation and soil erosion:

Deforestation carried out to create dry lands is one of the major concerns. Land that is once converted into a dry or barren land, can never be made fertile again, whatever the magnitude of measures to redeem it are. Land conversion, meaning the alteration or modification of the original properties of the land to make it use-worthy for a specific purpose is another major cause. This hampers the land immensely. Also there is a constant waste of land. Unused available land over the years turns barren; this land then cannot be used. So in search of more land, potent land is hunted and its indigenous state is compromised with.

3. Agricultural activities:

With growing human population, demand for food has increased considerably. Farmers often use highly toxic fertilizers and pesticides to get rid off insects, fungi and bacteria from their crops. However with the overuse of these chemicals, they result in contamination and poisoning of soil.

4. Mining activities:

During extraction and mining activities, several land spaces are created beneath the surface. We constant hear about land caving in; this is nothing but nature's way of filling the spaces left out after mining or extraction activity.

5. Industrialization:

Due to increase in demand for food, shelter and house, more goods are produced. This resulted in creation of more waste that needs to be disposed of. To meet the demand of the growing population, more industries were developed which led to deforestation. Research and development paved the way for modern fertilizers and chemicals that were highly toxic and led to soil contamination.

6. Construction activities:

Due to urbanization, large amount of construction activities are taking place which has resulted in large waste articles like wood, metal, bricks, plastic that can be seen by naked eyes outside any building or office which is under construction.

7. Nuclear waste:

Nuclear plants can produce huge amount of energy through nuclear fission and fus. The left over radioactive material contains harmful and toxic chemicals that can affect hum health. They are dumped beneath the earth to avoid any casualty.

8. Sewage treatment:

Large amount of solid waste is leftover once the sewage has been treated. The lefto material is sent to landfill site which end up in polluting the environment.

Effects of Land Pollution

1) **Soil pollution:** Soil pollution is another form of land pollution, where the upper layer of the soil is damaged. This is caused by the overuse of chemical fertilizers, soil erosion caused by running water and other pest control measures; this leads to loss of fertile land for agriculture, forest cover, fodder patches for grazing etc.
2) **Change in climate patterns:** The effects of land pollution are very hazardous and can lead to the loss of ecosystems. When land is polluted, it directly or indirectly affects the climate patterns.
3) **Environmental Impact:** When deforestation is committed, the tree cover is compromised on. This leads to a steep imbalance in the rain cycle. A disturbed rain cycle affects a lot of factors. To begin with, the green cover is reduced. Trees and plants help balance the atmosphere, without them we are subjected to various concerns like Global warming, the greenhouse effect, irregular rainfall and flash floods among other imbalances.
4) **Effect on human health:** The land when contaminated with toxic chemicals and pesticides lead to problem of skin cancer and human respiratory system. The toxic chemicals can reach our body through foods and vegetables that we eat as they are grown in polluted soil.
5) **Cause Air pollution:** Landfills across the city keep on growing due to increase in waste and are later burned which leads to air pollution. They become home for rodents, mice etc which in turn transmit diseases.
6) **Distraction for Tourist:** The city looses its attraction as tourist destination as landfills do not look good when you move around the city. It leads to loss of revenue for the state government.
7) **Effect on wildlife:** The animal kingdom has suffered mostly in the past decades. They face a serious threat with regards to loss of habitat and natural environment. The constant human activity on land, is leaving it polluted; forcing these species to move further away and adapt to new regions or die trying to adjust. Several species are pushed to the verge of extinction, due to no homeland.

Other issues that we face include increased temperature, unseasonal weather activity, acid rains etc. The discharge of chemicals on land, makes it dangerous for the ecosystem too. These chemicals are consumed by the animals and plants and thereby make their way in the ecosystem This process is called bio magnification and is a serious threat to the ecology.

Solutions for Land Pollution

- Make people aware about the concept of Reduce, Recycle and Reuse.
- Reduce the use of pesticides and fertilizers in agricultural activities.
- Avoid buying packages items as they will lead to garbage and end up in landfill site.
- Ensure that you do not litter on the ground and do proper disposal of garbage.

- Buy biodegradable products.
- Do Organic gardening and eat organic food that will be grown without the use of pesticides.
- Create dumping ground away from residential areas.

Landfills

Q: Differentiate between Sanitary and Industrial Landfills; also describe the land selection criteria for Landfills. (CSS-2016)

What are Landfills?

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Some landfills are well managed and designed as part of integrated waste management. However, most communities leave the landfills unattended to which cause land pollution and uncontrolled buildup of all sorts of solid waste materials. Here are the causes, effects, and solutions to landfills.

Serious Causes of Landfills

1) **Solid waste:** Solid waste is the number one contributor of landfill waste disposal. Homes, schools, restaurants, public places, markets, offices and so on produce a great deal of rubbish, garbage and used materials. The bulk of these wastes eventually end up in the landfills. Examples of the solid waste materials include wood, paper, plastic, broken furniture, glass, grounded cars, obsolete electronic products, and hospital and market waste.
2) Because most of these waste materials are non-biodegradable, they heap in the landfills where they stay for years. The scenario is even worse for poorly managed waste disposal systems and normally results in damage to the land and the surrounding environment.
3) **Agricultural waste:** Agricultural wastes arise from waste materials generated from animal manure, crop, and farm remains. The solid wastes like the animal manure and other agricultural by products are collected and dumped in the landfills. These agricultural remnants are highly toxic and can contaminate the land and water resources. Once in the landfills, the wastes remain there for years impacting on soil quality and polluting the land.
4) **Industry, manufacturing, and construction waste:** Industrial processes, construction activities and power plants produce a wide range of solid byproducts and residues. The predominant waste products are generated from oil refineries, power plants, construction works, pharmaceuticals, and agricultural product producers. The solid wastes usually find way to the landfills. As an example, oil refinery processes produce petroleum hydrocarbon byproducts while construction works generate wood, plastics, and metal wastes. Regardless of the fact that industrial manufacturing, power generation and construction works are regulated, their byproducts and residues from time to time find way to the landfills.
5) **Urbanization and population growth:** Increasing urbanization and population growth rate is considerably accountable for the increased number of landfills across the world. With the increase of population and urban growth, the demand for manufactured products and materials increases. As the demand increases, so does the increase of solid wastes. In

particular, plastic pollution has been on the rise in the first decade of this century due to rapid urbanization and population growth and most of the used plastic materials simply end up in the landfills. In most urban areas, plastics form the greater part of the landfills and constitute about 80% of all the municipal waste.

Drastic Effects of Landfills

1) **Air pollution and atmospheric effects:** There are more than ten toxic gases emitted from landfills, of which methane gas is the most serious. Methane gas is naturally produced during the process of organic matter decay. On this account, EPA records the methane expelled during the decomposition of organic matter in unmanaged landfills has the potential of trapping solar radiation 20 times more effective than carbon dioxide. The outcome is increased urban and global temperatures. Aside from the methane gas, other household and agricultural chemicals that find way to the landfills like bleach and ammonia can generate toxic gases that can greatly impact the air quality within the landfill vicinity. Dust, particulate matter and other non-chemical contaminates can also be expelled into the atmosphere, further contributing to air quality issues.
2) **Ground water pollution:** The primary environmental problem arising because of landfills is groundwater contamination from leaches. There are several hazardous wastes that find way into the landfills and once they are there, the inevitable is the natural deterioration of ground water. The toxic products in the landfills range from industrial solvents to household cleaners. Besides the chemicals from household and industrial products, electronic wastes contain lead, mercury and cadmium. A huge percentage of these landfill toxins infiltrate the soil to reach the fresh water waterways, which eventually end up in the domestic water and sadly enough, the foods that we consume. The pollution can also adversely harm animal and plant life. Research reveals that 82% of landfills have leaks.
3) **Health effects:** Increases in the risk of severe health implications such as birth defects, low birth weight, and particular cancers have been reported in individuals living next to landfill areas in numerous studies. For instance, TCE is a carcinogen element often originating from landfill leachate. Other discomfort and self-reported symptoms for people living next to the landfills include sleepiness, headaches and fatigue. The effects are linked with the toxic actions of the chemicals present in the landfill wastes. From contamination of the air with harmful gases to water pollution, the outcome is adverse human health effects. Landfill toxic gas releases and water pollution are as well associated with lung and heart diseases respectively.
4) **Soil and land pollution:** Landfills directly render the soil and land where it is located unusable. It also destroys the adjacent soil and land area because the toxic chemicals spread over the surrounding soil with time. The upper layer of the soil is damaged distorting soil fertility and activity and affecting plant life. Industrial and electronic wastes in the landfills destroy the quality of the soil and land thereby upsetting the land ecosystems.
5) **Economic costs:** The economic and social cost of landfill management is very high. From the management of the gases coming out of the landfills to groundwater contamination management, and ensuring compliance with environmental regulatory policies drains a lot of the municipality's and tax payer's money in terms of integrated waste management. Because most of the materials disposed in the landfills take millions of years to decompose, designing effective strategies and facilities for managing landfills requires high capital investments with regards to management and recycling initiatives.
6) **Landfill fires:** Landfill gases together with a substantive amount of landfill waste, can easily start a fire. Once fires are ignited, it can be challenging to put it out and further cause air pollution. If not put out immediately, they can get out of control and destroy the neighboring habitats. Methane is notably the most flammable and combustible gas in the landfill and as such, given its abundant supply it can create havoc. Combustion of the landfill even worsens the situation as the burning of the chemicals adds more chemical load to the area.

Impressive Solutions of Landfills

Design and implementation of integrated waste management

The construction of modern landfills with well-engineered and managed disposal facilities can significantly lessen the impacts of landfill on soil, air, and water. Landfills that are well-designed and operated ensure compliance with environmental preservation requirements and it ultimately ensures that the environment is free from contaminants.

The use of such designs also ensures the landfills are not located in environmentally-sensitive areas and are incorporated with on-site environmental monitoring systems. With on-site environmental monitoring systems, signs of land fill gas and groundwater contamination can be easily detected and controlled.

Recycle, Re-use, and reduce

Landfill management will always remain a major environmental if communities don't embrace the need of recycling, reducing and reuse. The increased demand of manufactured products is what increases the final waste products that end up in the landfill. In this view, the use of recycling systems for electronic wastes, plastics, paper, metal, glass and other non-biodegradable materials can provide an effective means of reducing the landfill effects.

Respect the planet: A deep gratitude and recognition of how beautiful the planet is, including the interdependence of living and non-living things will help us exploit the planet positively while also giving it time to flourish and rejuvenate.

Rethink our consumption needs: After huge purchases, we find out that most of the products don't make us as happy as we thought they would. In going about our life experiences, we should reconsider our consumption habits and also buy what we think is necessary and useful for the betterment of both our well-being and nature.

Reduce wastage: Spending our money on things we don't need drains our wallets and destroys our environment because of waste accumulation. Only spending on what is needed saves out planet and keeps it environmentally friendly. Furthermore, it contributes to a cleaner and more efficient environment since it establishes the need for meaningful production and distribution of manufactured products.

Reuse products: Reusing the products that we have already bought keeps them away from the landfill. We can buy used items from internet sites like E-bay, second-hand stores, garage sales, or otherwise donate the items that we don't use.

Recycle materials: Recycling is one of the best solutions for landfill management. Materials such as plastics, cans, paper and glass can be recycled.

Sanitary Landfill?

Sanitary landfills are sites where waste is isolated from the environment until it is safe. It is considered when it has completely degraded biologically, chemically and physically. In high-income countries, the level of isolation achieved may be high. However, such an expensive hig level of isolation may not be technically necessary to protect public health. Four basic condition should be met before a site can be regarded as a sanitary landfill The ways of doing this should be adapted to local conditions. The immediate goal is to meet, to the best extent possible, the fo stated basic sanitary landfill conditions, with a longer term goal to meet them eventually in full.

Industrial landfills

Landfills that accepts specified industrial wastes. In most cases industrial wast landfills are monofills associated with a specific industry or facility.

Noise Pollution

Noise is generally regarded as an unwanted sound or sound, which produces unpleasan effects on the ears. Noise is produced by household gadgets, vehicles on the road, jet planes, lou speakers etc. Noise produces severe adverse effects on the quality of man's surrounding and i therefore, considered to be polluting the environment. It is the loudness and duration of the nois which is disturbing and causes physical discomfort and damage to hearing.

The unit of measurement of intensity of sound is called decibel (dB). Our ear is sensitive to an extremely wide range of intensity from 0 to 180 db, 0dB being the threshold of hearing, whereas 140 dB marks the threshold of pain.

Sources of Noise Pollution

1. **Industrialization:** Most of the industries use big machines which are capable of producing large amount of noise. Apart from that, various equipment's like compressors, generators, exhaust fans, grinding mills also participate in producing big noise.
2. **Poor Urban Planning:** In most of the developing countries, poor urban planning also play a vital role. Congested houses, large families sharing small space, fight over parking, frequent fights over basic amenities leads to noise pollution which may disrupt the environment of society.
3. **Social Events:** Noise is at its peak in most of the social events. Whether it is marriage, parties, pub, or place of worship, people normally flout rules set by the local administration and create nuisance in the area. People play songs on full volume which makes the condition of people living nearby pretty worse. In markets, you can see people selling clothes via making loud noise to attract the attention of people.
4. **Transportation:** Large number of vehicles on roads, aero planes flying over houses, underground trains produce heavy noise and people get it difficult to get accustomed to that
5. **Construction Activities:** Under construction activities like mining, construction of bridges, dams, buildings, stations, roads, flyovers take place in almost every part of the world. These construction activities take place every day as we need more buildings, bridges to accommodate more people and to reduce traffic congestion.
6. **Household Chores:** Gadgets like TV, mobile, mixer grinder, pressure cooker, vacuum cleaners , washing machine and dryer, cooler, air conditioners are minor contributors to the amount of noise that is produced but it affects the quality of life of your neighborhood in a bad way.

Effects of Noise Pollution

1. **Hearing Problems:** Our ears can take in a certain range of sounds without getting damaged. Man made noises such as horns, machinery, airplanes and even vehicles can be too loud for our hearing range. Constant exposure to loud levels of noise can easily result in the damage of our ear drums and loss of hearing. It also reduces our sensitivity to sounds that our ears pick up unconsciously to regulate our body's rhythm.

2. **Health Issues:** Excessive noise pollution in working areas such as offices, construction sites, bars and even in our homes can influence psychological health. Studies show that the occurrence of aggressive behavior, disturbance of sleep, constant stress, fatigue and hypertension can be linked to excessive noise levels. These in turn can cause more severe and chronic health issues later in life.
3. **Sleeping Disorders:** Without a good night sleep, it may lead to problems related to fatigue and your performance may go down in office as well as at home. It is therefore recommended to take a sound sleep to give your body proper rest.
4. **Cardiovascular Issues:** Blood pressure levels, cardio-vascular disease and stress related heart problems are on the rise. Studies suggest that high intensity noise causes high blood pressure and increases heart beat rate as it disrupts the normal blood flow.
5. **Trouble Communicating:** High decibel noise can put trouble and may not allow two people to communicate freely. This may lead to misunderstanding and you may get difficult understanding the other person. Constant sharp noise can give you severe headache and disturb your emotional balance.
6. **Effect on Wildlife:** Wildlife faces far more problems than humans because noise pollution since they are more dependent on sound. Animals develop a better sense of hearing than us since their survival depends on it. The ill effects of excessive noise begin at home. Pets react more aggressively in households where there is constant noise.

Solution for Noise Pollution

1. To restrict vehicular horns upto a certain frequency, no high frequency horns must be sold in the markets
2. Have large size banners or boards with no horn or limited horn symbols
3. We can watch television programs, listen to radio or use the washing machines selectively to reduce noise in domestic sectors.
4. Use any absorbing materials, like carpets to minimize noise generated from felling of items within the house.
5. Prohibit the usage of loudspeakers in habitant zones unless necessary requirements, like engaging wide audiences, or functions.
6. Send automobiles for servicing and tuning regularly. Try to reduce noise levels too by fixing silencers.
7. Industries can maintain machines through proper lubrication
8. Barriers can be installed between sources of noise and receiver to attenuate noise levels. However, at very large distances, the barrier becomes less effective because of the possibility of refractive atmospheric effects.
9. Buildings can also be designed with suitable noise absorbing material for the walls, windows or ceilings.
10. The Green belt development can attenuate noise levels through the nature such as by shrubs and trees.

Noise Pollution in Pakistan

Noise levels in Pakistan have reached critical levels with average noise values of 76.5db being recorded in Karachi, 72.5 in Islamabad and 86 in Peshawar. While these values may not have reached astronomical levels, but if left unchecked it could cause widespread hearing defects, insomnia, indigestion, heart burn, ulcers, hypertension and psychological disorders. According to

WHO criteria, noise levels in residential area should be 45db, 55db in commercial areas and 65 in industrial areas. Note that these are the maximum levels and yet in our major cities, the value is at least 10-20db above WHO criteria.

The above mentioned facts highlight the deleterious effects noise pollution poses on population at large In Pakistan, unfortunately there is no legislation to deal with the noise emanating from railway engines, aircraft or airport or industrial or construction activities. Public complaints about noise pollution are often received in the federal and provincial Environmental Protection Agencies, but in the absence of national standards for a noise, these agencies do not take any legal action. The road traffic noise is another source of noise nuisance in urban areas of Pakistan; the situation is getting alarming with increase in traffic density on city roads, particularly in Karachi. At present, there are no national standards for prescribing noise limits for residential areas, industrial areas, commercial areas or silence zones. Most of the areas, particularly the urban side, are subjected to unacceptable noise conditions due to construction, manufacturing, traffic and recreational activities.

No national survey has been conducted to assess the noise level in cities. However, random tests in different cities showed that the noise level in most of the areas was a high as 70 to 90 dB (A), which is much higher than the acceptable limits. At present there is no specific and detailed legislation to control noise pollution. The government should pass the 'Noise Pollution Control Act' to meet special Pakistan condition. Apart from such kind of central legislation, there should be a city noise control code for all major cities in Pakistan. Creation of an unnecessary noise has to be prohibited and should be punishable under law which is made by the Pakistan Environmental Protection Agency (Pak - EPA) exercising its power under clause (d) of section of the Pakistan Environmental Protection Ordinance (PEPO). 1983

Greenhouse Effect *and* Global Warming

Q: Comment, Green House Effect is a blessing. Also discuss Enhanced Green House Effect and its relation with global warming. (CSS-2016)

Svante Arrhenius (1859-1927) was a Swedish scientist that was the first to claim in 1896 that fossil fuel combustion may eventually result in enhanced global warming. He proposed a relation between atmospheric carbon dioxide concentrations and temperature. He found that the average surface temperature of the earth is about 15°C because of the infrared absorption capacity of water vapor and carbon dioxide. This is called the natural greenhouse effect. Arrhenius suggested a doubling of the CO_2 concentration would lead to a 5°C temperature rise. He and Thomas Chamberlin calculated that human activities could warm the earth by adding carbon dioxide to the atmosphere. This research was a by-product of research of whether carbon dioxide would explain the causes of the great Ice Ages. This was not actually verified until 1987.

After the discoveries of Arrhenius and Chamberlin the topic was forgotten for a very long time. In the 1980's, finally, the global annual mean temperature curve started to rise. People began to question the theory of an upcoming new ice age. In the late 1980's the curve began to increase so steeply that the global warming theory began to win terrain fast. Environmental NGO's (Non-Governmental Organizations) started to advocate global environmental protection to prevent further global warming.

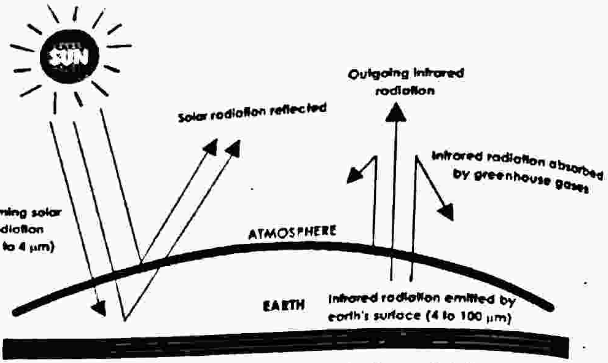
Stephen Schneider had first predicted global warming in 1976. This made him one of the world's leading global warming experts.

In 1988 it was finally acknowledged that climate was warmer than any period since 1880. The greenhouse effect theory was named and Intergovernmental Panel on Climate Change (IPCC) was founded by the United Nations Environmental Programme and the World Meteorological Organization. The IPCC is referred to as the largest peer-reviewed scientific cooperation project in history. In 1998 the Kyoto Protocol was negotiated in Kyoto, Japan. It requires participating countries to reduce their anthropogenic greenhouse gas emissions (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol was eventually signed in Bonn in 2001 by 186 countries. Several countries such as the United States and Australia have retreated. Pakistan has ratified the Kyoto Protocol on Climatic Change in 2004.

From 1998 onwards the terminology on the greenhouse effect started to change as a result of media influences. The greenhouse effect as a term was used fewer and fewer and people started to refer to the theory as either global warming or climate change.

Greenhouse Effect (CSS 1998, 2001, 2009)

The greenhouse effect results from the interaction between sunlight and the layer of greenhouse gases in the Earth's atmosphere that extends up to 100 km (60 mi) above Earth's surface. Sunlight is composed of a range of radiant energies known as the solar spectrum, which includes visible light, infrared light, gamma rays, X rays, and ultraviolet light. When the Sun's radiation reaches the Earth's atmosphere, some 25 percent of the energy is reflected back into space by clouds and other atmospheric particles. About 20 percent is absorbed in the atmosphere. For instance, gas molecules in the uppermost layers of the atmosphere absorb the Sun's gamma rays and X rays. The Sun's ultraviolet radiation is absorbed by the ozone layer, located 19 to 48 km (12 to 30 mi) above the Earth's surface.


SUN
Outgoing infrared radiation
Solar radiation reflected
Infrared radiation absorbed by greenhouse gases
Incoming solar radiation (0.2 to 4 μm)
ATMOSPHERE
EARTH
Infrared radiation emitted by earth's surface (4 to 100 μm)

About 50 percent of the Sun's energy, largely in the form of visible light, passes through the atmosphere to reach the Earth's surface. Soils, plants, and oceans on the Earth's surface absorb about 85 percent of this heat energy, while the rest is reflected back into the atmosphere—most effectively by reflective surfaces such as snow, ice, and sandy deserts. In addition, some of the Sun's radiation that is absorbed by the Earth's surface becomes heat energy in the form of long-wave infrared radiation, and this energy is released back into the atmosphere.

The heat-trapping gases in the atmosphere behave like the glass of a greenhouse. They let much of the Sun's rays in, but keep most of that heat from directly escaping. Because of this, they are called greenhouse gases. Without these gases, heat energy absorbed and reflected from the Earth's surface would easily radiate back out to space, leaving the planet with an inhospitable temperature close to −19°C (2°F), instead of the present average surface temperature of 15°C (59°F).

How Do Humans Contribute to the Greenhouse Effect?

While the greenhouse effect is an essential environmental prerequisite for life on Earth, there really can be too much of a good thing.

The problems begin when human activities distort and accelerate the natural process by creating *more* greenhouse gases in the atmosphere than are necessary to warm the planet to an ideal temperature.

- **Burning natural gas, coal and oil** -including gasoline for automobile engines-raises the level of carbon dioxide in the atmosphere.
- **Some farming practices and land-use changes** increase the levels of methane and nitrous oxide.
- **Many factories produce long-lasting industrial gases** that do not occur naturally, yet contribute significantly to the enhanced greenhouse effect and "global warming" that is currently under way.
- **Deforestation** also contributes to global warming. Trees use carbon dioxide and give off oxygen in its place, which helps to create the optimal balance of gases in the atmosphere. As more forests are logged for timber or cut down to make way for farming, however, there are fewer trees to perform this critical function.

- **Population growth** is another factor in global warming, because as more people use fossil fuels for heat, transportation and manufacturing the level of greenhouse gases continues to increase. As more farming occurs to feed millions of new people, more greenhouse gases enter the atmosphere.

Carbon Dioxide Emissions are the Biggest Problem

Currently, carbon dioxide accounts for more than 60 percent of the enhanced greenhouse effect caused by the increase of greenhouse gases, and the level of carbon dioxide in the atmosphere is increasing by more than 10 percent every 20 years. If emissions of carbon dioxide continue to grow at current rates, then the level of the gas in the atmosphere will likely double, or possibly even triple, from pre-industrial levels during the 21st century.

Some human activities also produce greenhouse gases and these gases keep increasing in the atmosphere. The change in the balance of the greenhouse gases has significant effects on the entire planet. Burning fossil fuels - coal, oil and natural gas - releases carbon dioxide into the atmosphere. Cutting down and burning trees also produces a lot of carbon dioxide. A group of greenhouse gases called the chlorofluorocarbons have been used in aerosols, such as hairspray cans, fridges and in making foam plastics.

The Greenhouse Effect

The greenhouse effect refers to the ability of the atmosphere to trap the sun's heat, increasing the temperature of the planet. When the sun's energy reaches Earth, the atmosphere absorbs some of it on the way down, and then absorbs more when that energy reflects back off the surface during the day. This trapped energy heats up the atmosphere, increasing the temperature of the planet and distributing warmth to its night side, when solar heating is unavailable. The denser the atmosphere, and the higher the concentration of energy-holding molecules like water vapor and carbon dioxide, the more energy the atmosphere can trap.

Positive Effects

The greenhouse effect is important, because it contributes to the survival of life on Earth. Without the greenhouse effect, the temperature of the planet would be similar to conditions experienced on the moon. On the lunar surface, with no atmosphere to mediate temperature swings, the surface can reach 134 degrees Celsius (273 degrees Fahrenheit) during the day and -153 degrees Celsius (-244 degrees Fahrenheit) at night. This dramatic temperature change required NASA to develop specialized gear to protect astronauts from both extremes for the moon landings. A similar temperature swing on Earth would have produced an environment hostile to most living things.

Too Much of a Good Thing

Unfortunately, while a moderate greenhouse effect is vital to life, an elevated greenhouse effect can be dangerous. Since the Industrial Revolution, the widespread adoption of fossil fuels has increased the amount of carbon dioxide, water vapor, and other greenhouse gases in the atmosphere. According to a study by the Carbon Dioxide Information Analysis Center of the United States Department of Energy, carbon dioxide levels have increased 39.5 percent since 1750, while levels of methane in the atmosphere have jumped by 150 percent. Climate scientists point to this increase in heat-trapping gases as one of the reasons global temperatures have risen during this period.

Extreme Effects

One of the chief concerns about an increase in the greenhouse effect is that the change can become self sustaining. As more greenhouse gases enter the atmosphere, its ability to trap heat increases. As the warmth of the atmosphere increases, the amount of water vapor it can hold increases as well, further boosting the effect. In addition, increased global temperatures may cause permafrost to release large amounts of carbon that is currently frozen into permafrost. Excessive heat retention could lead to massive changes in weather, exacerbating the problem. The effect of mitigating factors, such as distribution and available land mass on a global scale, and increased cloud cover reflecting sunlight back into space, is not well understood.

Deforestation

What do you understand by the term "deforestation"?

(CSS 1995)

Deforestation is a large-scale removal of forest prior to its replacement by other land uses. Forests are removed for a variety of reasons, including agriculture, timber harvesting, mining, and to make way for roads, dams, and human settlements. Deforestation poses a severe worldwide environmental problem. Forests take carbon dioxide from the atmosphere in the process of photosynthesis. The destruction of forests exacerbates the accumulation of carbon dioxide in the atmosphere, which then contributes to global warming. In addition, deforestation causes soil erosion and destabilizes water tables, resulting in flooding or drought.

Deforestation also reduces biodiversity, particularly significant in tropical forests that are home to a substantial portion of the world's plant and animal species. Deforestation processes are, in general, more destructive in the tropics. Most forest soils in the tropics are far less fertile than temperate soils, and more vulnerable to erosion. This is due to high rainfall, which leaches nutrients from the soil and speeds erosion.

Global Warming (CSS 1998, 2004, 2008, 2010, 2013)

Since there are more and more greenhouse gases in the atmosphere, more heat is trapped which makes the Earth warmer. This is known as global warming. A lot of scientists agree that man's activities are making the natural greenhouse effect stronger. If we carry on polluting the atmosphere with greenhouse gases, it will have very dangerous effects on the Earth. Today the increase in the Earth's temperature is increasing with unprecedented speed.

To understand just how quickly global warming is accelerating, consider that during the entire 20th century, the average global temperature increased by about 0.6 degrees Celsius *(slightly more than 1 degree Fahrenheit)*. Using computer climate models, scientists estimate that by the year 2100 the average global temperature will increase by 1.4 degrees to 5.8 degrees Celsius *(approximately 2.5 degrees to 10.5 degrees Fahrenheit)*.

The Effects of Global Warming

Global Warming is already affecting the human kind, plant and animals in number of ways through increased ocean levels, droughts and changed weather patterns. Global warming is well recognized by scientists around the world as a serious public health and environmental concern.

1. **Melting of glaciers.** The melting of glaciers will create plethora of problems for human kind an the animals living in the earth. Due to increased global warming, the level of the sea will rise which will lead to flooding and this will in turn create havoc in human life. Apart from raising the sea levels, it will also endanger several species of animals and th will hamper the balance of the ecosystem. Moreover these large glaciers reflect light back into the space and with meltdown of these glaciers, earth will be further warmed.
2. **Climate Change.** Irregular weather patterns have already started showing results. Increased precipitation in the form of rain has already been noticed in polar and subpolar regions. More global warming will lead to more evaporation which will cause more rains. Animals and plants cannot easily adapt to increase rainfall. Plants may die due to it and animals may migrate to other areas, which can cause entire ecosystem out of balance.
3. **Droughts.** Large scale evaporation will be the major cause of droughts in many places particularly Africa. Although, it is reeling under the huge pressure of water crisis, increased global warming would further make the situation worse and will cause malnutrition.
4. **Diseases:** As the temperature becomes more warm, it will have an effect on the health of humans and the diseases they are exposed to. With the increase in the rainfall, water borne diseases are likely to spread specially malaria. The earth will become more warm and as a result heat waves are likely to increase that will cause a major blow to the people.
5. **Hurricanes frequency:** As the temperature of the ocean rises, hurricanes and other storms are likely to become stronger. With the increase in the global warming the water in the ocean warms up and it heats up the surrounding air, creating hurricanes. More water evaporation means more hurricanes.
6. **Agriculture.** Global warming will affect agriculture. Although the results are not visible yet, but it may show its colors in years to come. As the global temperature will increase plants will find it harder to survive and will die. Plants are the major source of food for human beings and as a result food shortage will occur. The shortage of the food may lead to war and conflicts in some countries.
7. **People:** The changes in climate will affect everyone, but some populations will be at greater risk. For example, countries whose coastal regions have a large population, such as Egypt and China, may see whole populations move inland to avoid flood risk areas. The effect on people will depend on how well we can adapt to the changes and how much we can do to reduce climate change in the world.
8. **Plants and Animals:** It has taken millions of years for life to become used to the conditions on Earth. As weather and temperature changes, the homes of plants and animals will be affected all over the world. For example, polar bears and seals will have to find new land for hunting and living if the ice in the Arctic melts. Many animals and plants may not be able to cope with these changes and could die. This could cause the loss of some animal and plant species in certain or all areas of the world.

Arguments *against* Global Warming

Global warming is a controversial issue today. Some say that it has been overly hyped.

- It is argued that global warming is a minor issue because of which major issues like HIV/AIDS, Nuclear proliferation and poverty are not being devoted their deserved time and resources.
- Global warming is even argued to be merely a vested interest of scientists. It is said that scientists exaggerate the effects of global warming because they receive funds from environmental companies.
- Global warming is believed, also, to be the outcome of failed computer climate models. It is argued that these models are not able to predict even tomorrow's weather accurately, so

how can they predict long-term climate change?

- It is argued that human activities are not the only cause of global warming. There are other factors involved in global warming too.
- Detractors of global warming also hold that newspapers sensationalize global warming in order to sell. They distort the picture of global warming when actually that it is not as severe an issue as they make it out to be.
- Detractors also say that since scientists have made wrong predictions before, science and scientists are not always right. Perhaps they have made an error in their calculations and drawn incorrect conclusions on available evidence, thus making global warming a virtual rather than a real problem.
- Since we don't have long term historical records of the climate that Earth has witnessed, global warming could well be only a hypothesis.
- It is argued that water vapor plays a major part in global warming. Anthropogenic emissions of carbon dioxide, methane, hydrocarbons and other green-house gases have only a minor role to play. In fact, some people even believe that global warming is a natural phenomenon. Man has no role to play in it. Only our environment is responsible.
- The data on temperature increase that scientists keep producing as evidence is nothing to worry about because the increase in the temperature has in fact been gradual, spread over more than hundred years. Also, the earth was warmer before. That did not have harmful consequences on humans. Why will it now? In fact people argue that the increase in temperature will help plants grow in currently cold and uninhabitable areas. The increase in the level of carbon dioxide will also stimulate plant growth.
- Another common argument against global warming is that the upsurge in solar activity has caused global warming, not anthropogenic effects of development.
- One realizes that most of the arguments against global warming are factually incorrect or farfetched. People advocating these arguments have a vested interest in activities and industries that contribute to global warming. Unfortunately they are able to sway a section of the population into believing that global warming is not a serious issue.

Acid Rain

(CSS 1990, 2002, 2017, 2018)

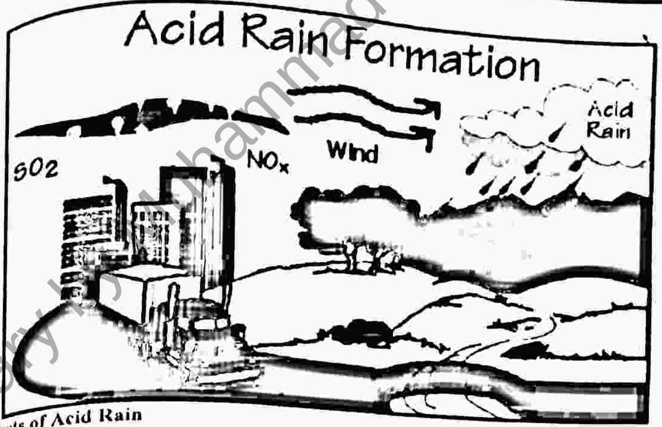
***Q:* What is 'Acid Rain'? Describe its causes and how it can be prevented.**

(CSS-2018)

***Q:* What is an Acid Rain and how it is produced. Briefly describe the dangers associated with it?**

(CSS-2017)

Acid Rain, form of air pollution in which airborne acids produced by electric utility plants and other sources fall to Earth in distant regions. The corrosive nature of acid rain causes widespread damage to the environment. The problem begins with the production of sulfur dioxide and nitrogen oxides from the burning of fossil fuels, such as coal, natural gas, and oil, and from certain kinds of manufacturing. Sulfur dioxide and nitrogen oxides react with water and other chemicals in the air to form sulfuric acid, nitric acid, and other pollutants. These acid pollutants reach high into the atmosphere, travel with the wind for hundreds of miles, and eventually return to the ground by way of rain, snow, or fog, and as invisible "dry" forms.



Effects of Acid Rain

The acids in acid rain react chemically with any object they contact. Acids are corrosive chemicals that react with other chemicals by giving up hydrogen atoms. The acidity of a substance comes from the abundance of free hydrogen atoms when the substance is dissolved in water. Acidity is measured using a pH scale with units from 0 to 14. Acidic substances have pH numbers from 1 to 6—the lower the pH number, the stronger, or more corrosive, the substance. Some nonacidic substances, called bases or alkalis, are like acids in reverse—they readily accept the hydrogen atoms that the acids offer. Bases have pH numbers from 8 to 14, with the higher values indicating increased alkalinity. Pure water has a neutral pH of 7—it is not acidic or basic. Rain, snow, or fog with a pH below 5.6 is considered acid rain.

1. **Soil:** In soil, acid rain dissolves and washes away nutrients needed by plants. It can also dissolve toxic substances, such as aluminum and mercury, which are naturally present in some soils, freeing these toxins to pollute water or to poison plants that absorb them. Some soils are quite alkaline and can neutralize acid deposition indefinitely; others, especially thin mountain soils derived from granite or gneiss, buffer acid only briefly.
2. **Trees:** By removing useful nutrients from the soil, acid rain slows the growth of plants, especially trees. It also attacks trees more directly by eating holes in the waxy coating of leaves and needles, causing brown dead spots. If many such spots form, a tree loses some of its ability to make food through photosynthesis. Also, organisms that cause disease can infect the tree through its injured leaves. Once weakened, trees are more vulnerable to other stresses, such as insect infestations, drought, and cold temperatures.
3. **Agriculture:** Most farm crops are less affected by acid rain than are forests. The deep soils of many farm regions can absorb and neutralize large amounts of acid.
4. **Surface Waters:** Acid rain falls into and drains into streams, lakes, and marshes. Where there is snow cover in winter, local waters grow suddenly more acidic when the snow

melts in the spring. Most natural waters are close to chemically neutral, neither acidic nor alkaline: their pH is between 6 and 8.

5. **Plants and Animals:** The effects of acid rain on wildlife can be far-reaching. If the population of one plant or animal is adversely affected by acid rain, animals that feed on that organism may also suffer. Ultimately, an entire ecosystem may become endangered. Some species that live in water are very sensitive to acidity, some less so
6. **Human-Made Structures:** Acid rain and the dry deposition of acidic particles damage buildings, statues, automobiles, and other structures made of stone, metal, or any other material exposed to weather for long periods. The corrosive damage can be expensive and, in cities with very historic buildings, tragic.
7. **Human Health:** The acidification of surface waters causes little direct harm to people. It is safe to swim in even the most acidified lakes. However, toxic substances leached from soil can pollute local water supplies

Efforts to Control Acid Rain

- Acid rain can best be curtailed by reducing the amount of sulfur dioxide and nitrogen oxides released by power plants, motorized vehicles, and factories. The simplest way to cut these emissions is to use less energy from fossil fuels.
- Individuals can help. Every time a consumer buys an energy-efficient appliance, adds insulation to a house, or takes a bus to work, he or she conserves energy and, as a result, fights acid rain.
- Another way to cut emissions of sulfur dioxide and nitrogen oxides is by switching to cleaner-burning fuels. For instance, coal can be high or low in sulfur, and some coal contains sulfur in a form that can be washed out easily before burning. By using more of the low-sulfur or cleanable types of coal, electric utility companies and other industries can pollute less.
- The gasoline and diesel oil that run most motor vehicles can also be formulated to burn more cleanly, producing less nitrogen oxide pollution. Clean-burning fuels such as natural gas are being used increasingly in vehicles. Natural gas contains almost no sulfur and produces very low nitrogen oxides.
- Pollution can also be reduced at the moment the fuel is burned. Several new kinds of burners and boilers alter the burning process to produce less nitrogen oxides and more free nitrogen, which is harmless. Limestone or sandstone added to the combustion chamber can capture some of the sulfur released by burning coal.
- Cleaning up sulfur dioxide and nitrogen oxides will reduce not only acid rain but also smog, which will make the air look clearer.

***Q:* What were the main objectives of Clean Development Mechanism? Also explain the reasons for the criticism on Kyoto Protocol by the developed countries.** (CSS-2017)

The Clean Development Mechanism

The Kyoto Protocol includes three flexibility mechanisms to enable its implementation. These mechanisms provide economically efficient alternatives for Annex I economies to reduce GHG emissions and meet their Kyoto targets. This module focuses on only one of these flexibility mechanisms: the Clean Development Mechanism (CDM). CDM projects are initiatives that result in a reduction of greenhouse gases. These projects must be implemented by Annex I economies in Non-Annex I economies where both parties have ratified the Kyoto Protocol. It also may be possible for Non-annex I economies to develop CDM projects to sell the credits they generate

This concept – called "unilateral CDM" is under debate. Article 12 of the Kyoto Protocol says that the CDM is intended to:

- Assist developing economies to achieve sustainable development;
- Assist industrialized economies to fulfill their emission reduction obligations under the Kyoto Protocol; and
- Contribute to global greenhouse gas reductions.

Objectives of Clean Development Mechanism

The CDM, defined in Article 12 of the Protocol, was intended to meet two objectives:

- (1) to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), which is to prevent dangerous climate change; and
- (2) to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments (greenhouse gas (GHG) emission caps).

The United States, the primary producer of carbon emissions in the world at the time, never ratified the treaty, rendering it ineffective because the US accounted for a quarter of the total international carbon output. American leaders have continually stated that the Kyoto Protocol could harm the American economy, cost American jobs, and decrease productivity by up to ten percent by 2010. The United States has faced increasing pressure from other countries regarding the decision not to ratify the treaty. The United States claims to be acting in its own interest; however, 42% of people surveyed by Gallup said that the US should ratify the Kyoto Protocol, compared to 22% who said that the US should not ratify the treaty. Thirty-six percent of those surveyed had no opinion. This creates domestic, as well as international, division. As of now, the Kyoto Protocol is the only legal document attempting to address climate change on an international level. By not participating in the treaty, the US is denying responsibility for a problem they helped to create, weakening their ties to other countries that have ratified the treaty, and ultimately causing itself more harm than good. The effects of global warming will eventually cost America millions in damage relief, international aid, and more expensive natural resources

Another criticism of the Kyoto Protocol is that it does not require developing countries to lower their carbon emissions. China, now the largest emitter of carbon, is not bound by the Kyoto Protocol to reduce production of carbon dioxide. They are, however, able to take advantage of the funding provision, which states that the group of developed countries must economically help developing countries tackle climate change. India, also a large contributor to global carbon emissions, is under no legal agreement to reduce their levels of emissions.

Ozone Layer *and* Ozone Depletion

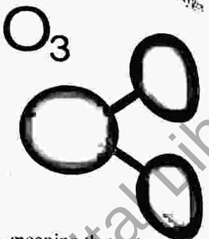
Ozone Layer, a region of the atmosphere from 19 to 48 km (12 to 30 mi) above Earth's surface. Ozone concentrations of up to 10 parts per million occur in the ozone layer. The ozone forms there by the action of sunlight on oxygen. This action has been taking place for many millions of years, but naturally occurring nitrogen compounds in the atmosphere apparently have kept the ozone concentration at a fairly stable level.

The ozone layer of the atmosphere protects life on Earth by absorbing harmful ultraviolet radiation from the Sun.

What is Ozone?

Ozone is a molecule composed of three oxygen atoms. The chemical symbol of ozone is O_3 as the symbol of oxygen atoms is O.

Most ozone found in our atmosphere is formed by an interaction between oxygen molecules and ultraviolet radiation emitted by the sun: (Oxygen molecules make up about 21% of all gases in the earth's atmosphere; they consist of two atoms of oxygen and are therefore labeled O_2).



When ultraviolet (UV) radiation hits an oxygen molecule, it may cause the molecule to break apart into single atoms of oxygen ($O_2 + UV \rightarrow O + O$). These atoms are very reactive, and a single oxygen atom can combine with a molecule of oxygen to form ozone ($O_2 + O \rightarrow O_3$).

The individual ozone molecules make up what we call "the ozone layer". It is not, however, an especially thick layer - there are usually less than three ozone molecules for every ten million molecules of air. That is why ozone is known as a trace gas, meaning that only trace (very small) amounts are present. We are fortunate that these small amounts make a big difference.

Where is it found?

The ozone layer is a concentration of ozone in the stratosphere, an area about 10 to 50 kilometers above the earth's surface. In this layer, there is about 90% of the planet's ozone. Stratospheric ozone is a natural gas that stops most of the sun's ultraviolet radiation from reaching the surface of the earth. A diminished ozone layer allows more radiation to reach the earth's surface, where it has many harmful effects.

The layer of the atmosphere below the stratosphere is called the troposphere. That's the region where the weather takes place. About 10% of all existing ozone is found in this level. Its presence has two reasons. First, ozone from the stratosphere occasionally "strays" from the stratosphere into the troposphere. However, a great deal of tropospheric ozone has its source right here on earth. It is a product of complex chemical reactions that partly involve components of car exhaust and wastes from power plants (for example carbon monoxide and nitrogen oxides). Thus ozone is often a key component of industrial smog, a common problem in many cities.

Scientists use a unit called the Dobson Unit (abbreviated DU) to describe the amount of ozone in the atmosphere.

Importance of Ozone

Ozone is a gas in the atmosphere that protects everything living on the Earth from harmful ultraviolet (UV) rays from the Sun. Without the layer of ozone in the atmosphere, it would be very difficult for anything to survive on the surface Plants cannot live and grow in heavy ultraviolet radiation, nor can the plankton that serve as food for most of the ocean life. The ozone layer acts as a shield to absorb the UV rays, and keep them from doing damage at the Earth's surface.

Ozone Depletion (CSS 1996)

Q: What do you mean by Ozone depletion and how we can prevent its depletion? (CSS-2017)

The ozone layer protects the Earth from the ultraviolet rays sent down by the sun. If the ozone layer is depleted by human action, the effects on the planet could be catastrophic. Ozone is present in the stratosphere. The stratosphere reaches 30 miles above the Earth, and at the very top it contains ozone. The sun's rays are absorbed by the ozone in the stratosphere and thus do not reach the Earth.

Ozone is a bluish gas that is formed by three atoms of oxygen. The form of oxygen that humans breathe in consists of two oxygen atoms, O_2. When found on the surface of the planet, ozone is considered a dangerous pollutant and is one substance responsible for producing the greenhouse effect.

The highest regions of the stratosphere contain about 90% of all ozone

In recent years, the ozone layer has been the subject of much discussion. And rightly so, because the ozone layer protects both plant and animal life on the planet.

The fact that the ozone layer was being depleted was discovered in the mid-1980s. The main cause of this is the release of CFCs, chlorofluorocarbons. Scientists were concerned when they discovered in the 1970s that chemicals called chlorofluorocarbons, or CFCs—long used as refrigerants and as aerosol spray propellants—posed a possible threat to the ozone layer. Released into the atmosphere, these chlorine-containing chemicals rise and are broken down by sunlight, whereupon the chlorine reacts with and destroys ozone molecules—up to 100,000 per CFC molecule. For this reason, the use of CFCs in aerosols has been banned in the United States and elsewhere. Other chemicals, such as bromine halocarbons, as well as nitrous oxides from fertilizers, may also attack the ozone layer. Destruction of the ozone layer is predicted to cause increases in skin cancer and cataracts, damage to certain crops and to plankton and the marine food web, and an increase in carbon dioxide due to the decrease in plants and plankton.

Antarctica was an early victim of ozone destruction. A massive hole in the ozone layer right above Antarctica now threatens not only that continent, but many others that could be the victims of Antarctica's melting icecaps. In the future, the ozone problem will have to be solved so that the protective layer can be conserved.

Causes of Ozone Depletion

Scientific evidence indicates that stratospheric ozone is being destroyed by a group of manufactured chemicals, containing chlorine and/or bromine. These chemicals are called "ozone-depleting substances" (ODS).

The **Main Ozone-Depleting Substances (CFCs)**

- **Chlorofluorocarbons (CFCs)**
    - The most widely used ODS, accounting for over 80% of total stratospheric ozone depletion.
    - Used as coolants in refrigerators, freezers and air conditioners in buildings and cars manufactured before 1995.
    - Found in industrial solvents, dry-cleaning agents and hospital sterilants.
    - Also used in foam products — such as soft-foam padding (*e.g.* cushions and

mattresses) and rigid foam (*e.g.* home insulation).

- **Halons**
    - Used in some fire extinguishers, in cases where materials and equipment would be destroyed by water or other fire extinguisher chemicals. In B.C., halons cause greater damage to the ozone layer than do CFCs from automobile air conditioners.
- **Methyl Chloroform**
    - Used mainly in industry — for vapour degreasing, some aerosols, cold cleaning, adhesives and chemical processing.
- **Carbon Tetrachloride**
    - Used in solvents and some fire extinguishers.
- **Hydrofluorocarbons (HCFCs)**
    - HCFCs have become major, "transitional" substitutes for CFCs. They are much less harmful to stratospheric ozone than CFCs are. But HCFCs they still cause some ozone destruction and are potent greenhouse gases.

Possible Effects of Ozone Depletion

Stratospheric ozone filters out most of the sun's potentially harmful shortwave ultraviolet (UV) radiation. If this ozone becomes depleted, then more UV rays will reach the earth. Exposure to higher amounts of UV radiation could have serious impacts on human beings, animals and plants such as the following:

- **Harm to human health:**
    - More skin cancers, sunburns and premature aging of the skin.
    - More cataracts, blindness and other eye diseases: UV radiation can damage several parts of the eye, including the lens, cornea, retina and conjunctiva.
    - Cataracts (a clouding of the lens) are the major cause of blindness in the world. A sustained 10% thinning of the ozone layer is expected to result in almost two million new cases of cataracts per year, globally (Environment Canada, 1993).
    - Weakening of the human immune system (immunosuppression). Early findings suggest that too much UV radiation can suppress the human immune system, which may play a role in the development of skin cancer.
- **Adverse impacts on agriculture, forestry and natural ecosystems:**
    - Several of the world's major crop species are particularly vulnerable to increased UV, resulting in reduced growth, photosynthesis and flowering. These species include wheat, rice, barley, oats, corn, soybeans, peas, tomatoes, cucumbers, cauliflower, broccoli and carrots.
    - The effect of ozone depletion on the Canadian agricultural sector could be significant.
    - Only a few commercially important trees have been tested for UV (UV-B) sensitivity, but early results suggest that plant growth, especially in seedlings, is harmed by more intense UV radiation.
- **Damage to marine life:**
    - In particular, plankton (tiny organisms in the surface layer of oceans) are threatened by increased UV radiation. Plankton are the first vital step in aquatic food chains.
    - Decreases in plankton could disrupt the fresh and saltwater food chains, and lead to a species shift in Canadian waters.
    - Loss of biodiversity in our oceans, rivers and lakes could reduce fish yields for commercial and sport fisheries.

Ozone Control Strategies

Growing concern for ozone depletion led to the adoption of the Montreal Protocol in 1987, in order to reduce and control industrial emission of chlorofluorocarbons (CFCs). Such international agreements have succeeded to a great extent in reducing the emission of these compounds. However, more cooperation and understanding among all the countries of the world is required to mitigate the problem. You too can do your bit to save the ozone. Use/buy more recycled products, save energy, take public transport, and, most importantly, spread awareness. Our individual efforts can go a long way in saving the Earth's blanket.

Water—Logging and Salinity (CSS 1989)

Rising water table on earth surface is called waterlogging. The word salinity is deduced from saline/ salt. The surplus of salt present on earth surface is known as salinity.

What is Salinity?

Salinity occurs when salty groundwater is close to or at the surface of the soil. When the water table is within two meters of the surface it is within the root zone of many plants. Air pores in the soil act like a sponge and the salty water is drawn up to the soil surface. This is called capillary rise. Damage to buildings, roads and plants is usually a combination of salt and waterlogging.

There are different causes of salinity:

- Dryland salinity;
- Irrigation salinity; and
- Urban salinity.

The salt in groundwater can come from:

- Rainfall (cyclic salt in the water cycle)
- The weathering of rock including old sea sediments
- Wind blown (aeolian) salt crystals from oceans and salt lakes

If the water table rises, salt crystals in the soil will be dissolved and enter the groundwater. Once the salt is dissolved in the groundwater, the salt goes where the groundwater goes.

Water-Logging

- Waterlogging occurs when roots cannot respire due to excess water in the soil profile.
- Water does not have to appear on the surface for waterlogging to be a potential problem.
- Improving drainage from the inundated paddock can decrease the period at which the crop roots are subjected to anaerobic conditions.
- While raised beds are the most intensive management strategy, they are also the most effective at improving drainage.
- Waterlogged soils release increased amounts of nitrous oxide (N_2O), a particularly damaging greenhouse gas.

Waterlogging occurs whenever the soil is so wet that there is insufficient oxygen in the pore space for plant roots to be able to adequately respire. Other gases detrimental to root growth, such as carbon dioxide and ethylene, also accumulate in the root zone and affect the plants. Plants differ in their demand for oxygen. There is no universal level of soil oxygen that can identify waterlogged conditions for all plants. In addition, a plant's demand for oxygen in its root zone will vary with its stage of growth.

Symptoms and Causes

- Lack of oxygen in the root zone of plants causes their root tissues to decompose. Usually this occurs from the tips of roots, and this causes roots to appear as if they have been pruned. The consequence is that the plant's growth and development is stalled. If the anaerobic circumstances continue for a considerable time the plant eventually dies.
- Most often, waterlogged conditions do not last long enough for the plant to die. Once the waterlogging event has passed, plants recommence respiring. As long as soil conditions are moist, the older roots close to the surface allow the plant to survive. However, further waterlogging-induced root pruning and/or dry conditions may weaken the plant to the extent that it will be very poorly productive and may eventually die.
- Many farmers do not realise that a site is waterlogged until water appears on the soil surface However, by this stage, plant roots may already be damaged and yield potential severely affected.

Q: Briefly explain the main reasons of water-logging in Pakistan. (CSS-2017)

Water—Logging and Salinity in Pakistan

Water logging and salinity is one of the most severe restrictions in Pakistan's agricultural productivity of Irrigated lands. Water logging and salinity has been eroding the potential agricultural productivity. Water logging is the major problem which causes the lower production of agricultural crops in Pakistan. Water logging and salinity affects 25% of irrigated land in Pakistan, reducing crop yields. It has been reported that 48% of the soils in Sindh and Punjab are saline while 18% of the soils are strongly saline.

Crops yield losses in Pakistan due to water-logging and salinity are feared to reach Rs8 million ($28.5 million) in 2012-2013, while total annual economic damage is estimated at $30 million. Yield losses of wheat in moderately saline areas of the country average about 65 per cent.

Causes of water Logging

Pakistan has one of the best canal systems in Pakistan. It is composed of 40790 canal miles. But some defects were found. It has created the twin problems of water logging. Some of the causes are:

1. These canals were not lined during construction. Therefore, seepage of water took place. It raises the water table of soil.
2. Our farmers have adopted unscientific irrigation system. Most of the water is collected in the ditches in the field. It causes water logging.
3. Monsoon rain and frequent floods form small lakes and ponds also cause water logging. There is a lack of drainage system. Thus this accumulated water cannot be drained out. This water gradually seeped downwards and reached the water table. Thus it raises the ground water surface.

Effects of water logging

There are following effects of water logging and salinity:

1. Water logging and salinity destroy the soil structure. Different layers of the soil are badly affected.
2. The soil is saturated with water. Therefore, the oxygen content of the soil is decreased. Thus oxygen is not available to the roots of the plants for respiration. So the plants die.
3. It causes anaerobic condition in the soil. Thus anaerobic microorganisms are produced in it. The anaerobic microorganisms produce methane (CH_4) and hydrogen sulphide (H_2S). These gases produce foul smell. They make the soil unfit for other beneficial soil

organisms.

4. The number of aerobic organisms is reduced in waterlogged soil. It reduces the decomposition of the organic matter of the soil. It causes deficiency of nitrogen in the waterlogged soil.
5. It causes deflocculation of soil. Water causes leaching of the soluble salts. Thus the upper Soil layer is without nutrients.
6. The soil pH become high and osmotic pressure is increased. It badly affects the plants and other soil organisms.
7. Waterlogging is also injurious to public health. Mosquitoes and flies breed in waterlogged area. They spread malaria and other water borne diseases.
8. The farmers cannot construct their houses in waterlogged areas. The houses sink in the ground in these areas. Waterlogging also destroying the houses in villages, towns and cities. Cities of Peshawar and Faisalabad are badly affected by these problems.

Effects of water logging in Pakistan

Most of the plants cannot grow in waterlogged and saline conditions.

Therefore, most of land of Pakistan has become barren. Water logging is destroying our irrigated lands rapidly. It can be compared with the cancer in the human body. We are unable to achieve self-sufficiency in food due to waterlogging. Most fertile and valuable lands of the country have wasted. The farmers are facing innumerable problems. It is badly affecting our economy. Waterlogging is affecting our lands at the rate of an acre a minute. According to a rough estimate it is affecting our lands at the rate of 1 lakh acre every year. There are total forty million acres of our irrigated areas. 5 million acres are seVerely affected by salinity. 12 million acres are suffering from salinity patches. 15 million acres are poorly drained or waterlogged.

Saline Soil (CSS 1989)

Saline soils are soils that contain high concentrations of soluble salts: sodium sulphate (Glauber's salts), magnesium sulphate (epsom salts), calcium sulphate (gypsum) and some sodium chloride (table salt), but have normal pH values. Saline soils are not to be confused with alkaline. Alkaline soils have low concentrations of soluble salts but are characterized by pH levels greater than 8.5. This high pH is caused by sodium (Na) ions attached to the clay particles.

Pakistan has more than 5.727mh of salt affected land, which is mainly situated in Indus plain, where about 4.2mh of land is affected by salinity and water-logging .3 million acres falling in the canal commanded area, while 11 million acres outside it. Salinity stress is a major environmental factor that drastically affects the crop productivity throughout the world. It is a menace to both agriculture and the soil body. The accumulation of topsoil changes its physical, chemical and biological characteristics. These soils have a preponderance of Na+on the soil complex resulting in compaction, decreased permeability to water and exclusion of air from the soil pores. Such condition are inimical to the growth of plants and even other useful organisms such as bacteria, fungi and other micro flora and fauna which are so essential for fertility and productivity of a soil

Numerous secondly effects of the saline and sodic condition of the soil adversely affect the ecology and the environment.

- The salinity stress problem arises when semi-arid or arid lands are subjected to cultivation either because the soils are already saline and/or irrigated with saline water, which adds to the salinity of the soil.
- In addition the excessive use of chemical fertilisers and irrigation have turned hundreds

of hectors of cultivated fertile lands in to saline lands-plants responses to salinity depend on the kinds of salts (SO42- And chlorides) contributing to salinity as well as the total electrolyte concentrations.

The aim of reclamation is to remove salinity and saline/sodicity from the root zone within possible limits so as to restore the productivity salt affected soils.

Reclamation technology involves four essential steps:

1. Adequate lowering of the water table
2. Leaching excessive salt out of the root zone
3. Attainment of satisfactory water infiltration
4. Scientific management of soil and water.

Saline soil can't reclaim by any chemical amendment, conditioner, or fertiliser.
Reclamation of these soil consist of simply applying enough high-quality water to leach the soil thoroughly, but now these days, due to shortage of irrigation water, it is to much difficult to facilitates enough high quality water practice in reclamation processes.

Reclaiming sodic and saline and sodic soils:

- Amendment should be used only when needed or when past results justify their use they may be useful where soil permeability is low due to low salinity excess sodium or high carbonate / bicarbonate in the water.
- However, they will not be useful if poor permeability exists due to problems with soil texture, soil compaction, restrictive layers (hardpans, claypans) or high water tables. If sodic soil contains no source of calcium (gypsum of free CO3) then gypsum or a
- If sodic soil contains no source of calcium (gypsum of free CO3) then gypsum or a soluble Ca source should be applied Ca amendment include gypsum (hydrated calcium sulphate) and calcium chloride. Gypsum is moderately soluble in water.
- It requires about one acres foot of water/acre to dissolve one ton gypsum/acre.
- Calcium chloride is highly water-soluble and fast acting, but it generally is too expensive to use.
- Gypsum found in very fine particles, the particle gypsum reacts more quickly to replace sodium because they are more soluble then the coarse gypsum usually applied.
- Gypsum is the slowest of the all amendments.
- If the soil contains lime, then acid or acid-forming materials can be used.
- Examples of acid or acid-forming materials include sulfuric acid, elemental sulfur, ferric sulfate and lime sulfur acid reacts immediately with the soil calcium carbonate (line).
- To release the soluble calcium to exchange with the sodium. Elemental sulfur must be oxidised by soil bacteria and react with water to form sulfuric acid (H2SO4).

Introduction

Waste has been a major environmental issue everywhere since the industrial revolution. Besides the waste we create at home, school and other public places, there are also those from hospitals, industries, farms and other sources. Humans rely so much on material things and they all (almost) end up as waste. And hey — where does the waste end up?

What is waste (trash, garbage, rubbish, refuse?)

Waste are items we (individuals, offices, schools, industries, hospitals) don't need and discard. Sometimes there are things we have that the law requires us to discard because they can be harmful. Waste comes in infinite sizes—some can be as small as an old toothbrush, or as large as the body of a school bus.

Everyone creates waste, although some people are very environmentally conscious and create very little. Likewise, some countries do a very good job creating less waste and managing the rest. Others are pretty horrible and have created huge environmental problems for the people and animals living there.

Difference between Trash and Garbage

Trash: Solid waste form places like your atic, backyard or study. Trash items include paper and card boxes and the like.

Garbage: This is waste from kitchen and bathroom. They also include waste from cooking food and from food storage facilities.

All over the world, communities handle their waste or trash differently. Some common methods of managing their waste include landfilling, recycling and composting. Other communities strongly embark on waste reduction and litter prevention/control aimed at reducing the production of waste in the first place. Some communities also engage in waste-to-energy plants and hazardous waste disposal programs.

Types of waste

Generally, waste could be liquid or solid waste. Both of them could be hazardous. Liquid and solid waste types can also be grouped into organic, re-usable and recyclable waste. Let us see some details below:

Liquid Type:

Waste can come in non-solid form. Some solid waste can also be converted to a liquid waste form for disposal. It includes point source and non-point source discharges such as storm water and wastewater. Examples of liquid waste include wash water from homes, liquids used for cleaning in industries and waste detergents.

Solid Type:

Solid waste predominantly, is any garbage, refuse or rubbish that we make in our homes and other places. These include old car tires, old newspapers, broken furniture and even food waste. They may include any waste that is non-liquid.

Hazardous Type:

Hazardous or harmful waste are those that potentially threaten public health or the environment. Such waste could be ***inflammable*** *(can easily catch fire)*, ***reactive*** *(can easily explode)*, ***corrosive*** *(can easily eat through metal) or* ***toxic*** *(poisonous to human and animals)*. In many countries, it is required by law to involve the appropriate authority to supervise the disposal of such hazardous waste. Examples include fire extinguishers, old propane tanks, pesticides, mercury-containing equipment (e.g. thermostats) and lamps (e.g. fluorescent bulbs) and

Organic Type:

Organic waste comes from plants or animals sources. Commonly, they include food waste, fruit and vegetable peels, flower trimmings and even dog poop can be classified as organic waste. They are biodegradable (this means they are easily broken down by other organisms over time and turned into manure). Many people turn their organic waste into compost and use them in their gardens.

Recyclable Type:

Recycling is processing used materials (waste) into new, useful products. This is done to reduce the use of raw materials that would have been used. Waste that can be potentially recycled is termed "Recyclable waste". Aluminum products (like soda, milk and tomato cans), Plastics (grocery shopping bags, plastic bottles), Glass products (like wine and beer bottles, broken glass), Paper products (used envelopes, newspapers and magazines, cardboard boxes) can be recycled and fall into this category.

Sources of Waste

Municipal sources of waste:

This includes trash or garbage from households, schools, offices, market places, restaurants and other public places.

They include everyday items like food debris, used plastic bags, soda cans and plastic water bottles, broken furniture, grass clippings, product packaging, broken home appliances and clothing.

Medical/Clinical sources of waste:

Medical/clinical waste, normally refers to waste produced from health care facilities, such as hospitals, clinics, surgical theaters, veterinary hospitals and labs. They tend to be classified as hazard waste rather than general waste.

Items in this group include surgical items, pharmaceuticals, blood, body parts, wound dressing materials, needles and syringes

Agricultural sources of waste:

Typically, this is waste generated by agricultural activities. These include horticulture, fruit growing, seed growing, livestock breeding, market gardens and seedling nurseries.

Waste items in this group include empty pesticide containers, old silage wrap, out of date medicines and wormers, used tires, surplus milk, cocoa pods and corn husks.

End-of-life Automobiles:

When cars are all old and not working again, where do they end up? Many people just leave them to rust in the fields, but there is a better way to deal with them. In many cities, these

vehicles are sent to the plant, where all the removable parts are taken out for recycling. The rest is flattened up and shredded into peices for recycling. The last bits that cannot be used again is sent to a landfill.

Industrial sources of waste:

Since the industrial revolution, the rise in the number of industries manufacturing glass, leather, textile, food, electronics, plastic and metal products has significantly contributed to waste production. Take a look at the things in your home, every item there was probably manufactured and possibly, waste was produced as a result.

Construction/demolition sources of waste:

Construction waste is that resulting from the construction of roads and building. Sometimes old buildings and structures are pulled down (demolished) to make space for new ones. This is particularly common in old cities that are modernizing. This is called demolition waste.

Waste items include concrete debris, wood, earth, huge package boxes and plastics from the building materials and the like.

Electronic sources of waste:

This is waste from electronic and electrical devices. Think of DVD and music players, TV, Telephones, computers, vacuum cleaners and all the other electrical stuff in your home. These are also called e-waste, e-scrap, or waste electrical and electronic equipment (WEEE)

Some e-waste (like TV) contains lead, mercury, cadmium, and brominated flame retardants. These are harmful to humans and the environment. It is therefore important that the right authorities ensure the proper disposal of such waste.

How is waste treated and disposed off?

Waste management simply means the collection, transport, processing or disposal, managing and monitoring of waste materials to minimize its' consequences on humans and environment.

There are several methods of managing all the various types of waste. Some of these methods cause additional harm to the environment, but not doing anything is not an option.

Let us see below two common ways of managing waste:

Incineration method of waste management:

This simply means burning waste. This method is common in countries with limited landfill space. Incineration chambers can be small for domestic use, but ther are large ones for municipal use as well. It is great for treating waste with contamination (like those from hospitals) and hazardous waste from factories, but the method produces too much carbon dioxide. Modern incineration processes are more efficient and release less dioxin than home fireplaces and backyard barbecues. This method is very common in Denmark, Germany and the Netherlands. This method is effective, but expensive.

Sanitary Landfills as waste disposal:

Generally, this term means a large piece of land away from living places where all the waste from a town is deposited. But there is more to landfills. Proper landfill management involves sorting out all the waste (waste separation), and sending only the waste that cannot be recycled and composted to the site.

Proper landfills, are also lined at the bottom to minimize the leakage of soil pollutants and other toxins from getting into the water table. This method is effective, but expensive and difficult.

In many towns, sorting is not done, and all the waste (paper, food, diapers, glass, mixed up and deposited. That is a problem because, glass, and plastics take thousands of years decompose. Additionally, the landfills soon become full, smelly and unsafe for the environment Proper waste management is not cheap, but it is something we all have to get involved discuss it. The effect of not getting involved can be catastrophic to our health and environment

Pakistan scenario of Solid Waste Management

Solid waste generation in Pakistan ranges between 0.283 to 0.612 kg/capital /day and waste generation growth rate is 2.4 percentage per year. Solid domestic waste is typically dumped on low-lying land. This land could be used for more productive purposes and potentially valuable recyclable materials are lost. The following are the main problems regarding solid waste management in Pakistan. There is no proper waste collection system. Waste is dumped on the streets. Different types of waste are not collected separately. There are no controlled sanitary landfill sites.

Problems

Solid waste generation in Pakistan ranges between 0.283 to 0.612 kg/capita/day and the waste generation growth rate is 2.4% per year. Solid domestic waste is typically dumped on low lying land. This land could be used for more productive purposes and potentially valuable recyclable materials are lost.

The following are the main problems regarding solid waste management in Pakistan:

- There is no proper waste collection system
- Waste is dumped on the streets
- Different types of waste are not collected separately
- There are no controlled sanitary landfill sites
- Citizens are not aware of the relationship between ways of disposing off waste and the resulting environmental and public health problems

Effects

The unavailability of proper disposal methods and resources for solid waste management results in various environmental and human health hazard effects. Problems can spread over a wide area.

Health Hazards

- Skin and eye infections are common
- Dust in the air at dumpsites can cause breathing problems in children and adults
- Flies breed on uncovered piles of rotting garbage and spread diseases like diarrhea dysentery, typhoid, hepatitis, and cholera. Mosquitoes transmit many types of disease like malaria and yellow fever
- Dogs, cats and rats living around refuse carry a variety of diseases including plague as flea born fever
- Intestinal, parasitic and skin diseases are found in workers engaged in collecting refuse

Ground water pollution

The most serious problem is groundwater contamination. As water filters through a material, chemicals in the material may dissolve in the water, a process called leaching. The resulting mixture is called leachate. As water percolates through MSW, it makes a leachate that consists of decomposing organic matter combined with iron, mercury, lead, zinc, and other metals from rusting cans, discarded batteries and appliances. It may also contain paints, pesticides cleaning fluids, newspaper inks, and other chemicals. Contaminated water can have a serious impact on all living creatures, including humans, in an ecosystem.

Air pollution

When waste is burnt heavy metals like lead, toxic gases and smoke spreads over residential areas. The wind also carries waste, dust and gases caused by decomposition. Putrefaction of waste in sunlight during daytime results in bad smells and reduced visibility.

The solution

There is an urgent need to manage MSW from the time it is created to its safe disposal. The public and local municipal authorities need to work together. It is important to create awareness about the consequences of pollution so that people become conscious of the need to deal with this problem.

Legislation

According to a World Bank report, Pakistan has responded to its environmental problems by developing laws, establishing Government agencies and accepting technical assistance from donors, including the World Bank. Despite this, the response remains fragmented and environmental institutions, laws, and other initiatives do not solve the whole problem.

Environmental legislation is still not well developed in Pakistan, especially in comparison to the developed world. For example, there are no national quality standards for MSW.

Install waste disposal facilities

Currently, individuals dispose off wastes by throwing away plastic bags, wrappers, fruit peels, cigarette butts, etc, in public places. Littering spreads pollution and ends up clogging drains and causing sanitation problems. This can be controlled by making roadside dustbins or proper disposal of waste at home. If proper waste management is practiced, this waste could be converted into useful products.

Reduce

The best way to reduce waste is not to produce it in the first place. Everyone should try to reduce his/her consumption of goods as much as possible. For example, choose products with minimum packaging and instead of accepting plastic bags when shopping, use cloth bags.

Reuse

Items should not just be thrown away after use if they can be used again. Doing this results in a reduction in waste and better conservation of resources. Items, which can be re-used, include glass jars and bottles, and plastic bags.

Recycle

Recycling means creating new things from used items. Almost 20-30 per cent of MSW contains materials which could be recycled. For instance:

- Paper can be re-pulped and reprocessed into recycled paper, cardboard and other paper products.
- Broken glass can be crushed, re-melted and made into containers.
- Some forms of plastic can be re-melted and fabricated into carpet fiber or cloth.
- Food wastes and yard wastes can be composted to produce fertilizers and soil conditioners.

remote sensing

Generally, remote sensing refers to the activities of recording/observing/perceiving (*sensing*) objects or events at far away (*remote*) places. In remote sensing, the *sensors* are not in direct contact with the objects or events being observed. The information needs a physical carrier to travel from the objects/events to the sensors through an intervening medium. The *electromagnetic radiation* is normally used as an information carrier in remote sensing. The output of a remote sensing system is usually an *image* representing the scene being observed. A further step of *image analysis and interpretation* is required in order to extract useful information from the image. The human *visual system* is an example of a remote sensing system in this general sense.

The United Nations in their annex Principles Relating to Remote Sensing of the Earth from Space defines it as:
(this definition is part of the General Assembly Resolutions and International Treaties
Pertaining to the Peaceful Uses of Outer Space)

> "The term **Remote Sensing** means the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment."

F.F. Sabins in his book "Remote sensing: principles and interpretation" defines it as follows:

> "**Remote Sensing** is the science of acquiring, processing and interpreting images that record the interaction between electromagnetic energy and matter."

These *remote sensing satellites* are equipped with sensors looking down to the earth. They are the "eyes in the sky" constantly observing the earth as they go round in predictable *orbits*.

Effects of Atmosphere

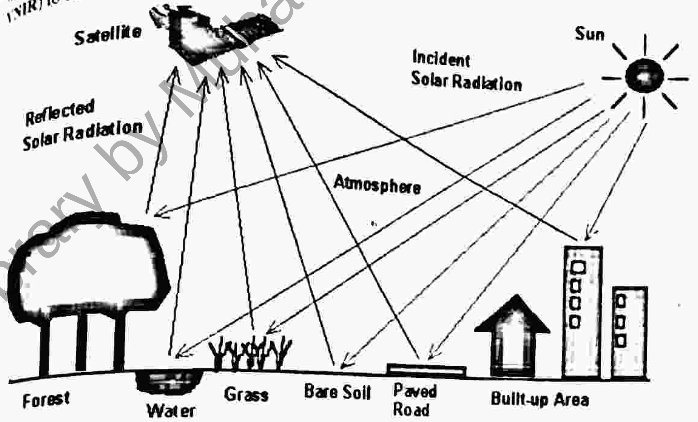
In satellite remote sensing of the earth, the sensors are looking through a layer of *atmosphere* separating the sensors from the Earth's surface being observed. Hence, it is essential to understand the effects of atmosphere on the electromagnetic radiation travelling from the Earth to the sensor through the atmosphere. The *atmospheric constituents* cause wavelength dependent *absorption* and *scattering* of radiation. These *effects* degrade the quality of images. Some of the atmospheric effects can be corrected before the images are subjected to further analysis and interpretation.

A consequence of atmospheric absorption is that certain wavelength bands in the electromagnetic spectrum are strongly absorbed and effectively blocked by the atmosphere. The wavelength regions in the electromagnetic spectrum usable for remote sensing are determined by their ability to penetrate atmosphere. These regions are known as the *atmospheric transmission windows*. Remote sensing systems are often designed to operate within one or more of the atmospheric windows. These windows exist in the microwave region, some wavelength bands in the infrared, the entire visible region and part of the near ultraviolet regions. Although the

mosphere is practically transparent to x-rays and gamma rays, these radiations are not normally sed in remote sensing of the earth.

Optical and Infrared Remote Sensing

In *Optical Remote Sensing*, optical sensors detect *solar radiation* reflected or scattered om the earth, forming images resembling photographs taken by a camera high up in space. The avelength region usually extends from the *visible and near infrared* (commonly abbreviated as VNIR) to the **short-wave infrared (SWIR)**.



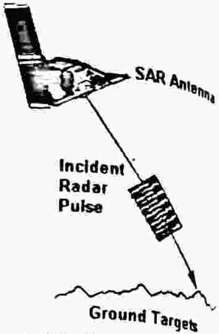
Different materials such as water, soil, vegetation, buildings and roads reflect visible and infrared light in different ways. They have different colours and brightness when seen under the sun. The *interpretation* of optical images require the knowledge of the *spectral reflectance signatures* of the various materials (natural or man-made) covering the surface of the earth.

There are also *infrared* sensors measuring the thermal infrared radiation emitted from the earth, from which the land or sea surface temperature can be derived.

Microwave Remote Sensing

There are some remote sensing satellites which carry passive or active *microwave sensors*. The active sensors emit pulses of *microwave radiation* to illuminate the areas to be imaged. Images of the earth surface are formed by measuring the microwave energy scattered by the ground or sea back to the sensors. These satellites carry their own "flashlight" emitting microwaves to illuminate their targets. The images can thus be acquired day and night. Microwaves have an additional advantage as they can penetrate clouds. Images can be acquired even when there are clouds covering the earth surface.

A microwave imaging system which can produce high resolution image of the Earth is the *synthetic aperture radar (SAR)*. The intensity in a SAR image depends on the amount of microwave backscattered by the target and received by the SAR antenna. Since the physical mechanisms responsible for this backscatter is different for microwave, compared to visible/infrared radiation, the *interpretation* of SAR images requires the knowledge of how microwaves interact with the targets.



Remote Sensing Images

Remote sensing images are normally in the form of *digital images*. In order to extract useful information from the images, *image processing* techniques may be employed to *enhance* the image to help visual interpretation, and to *correct* or *restore* the image if the image has been subjected to geometric distortion, blurring or degradation by other factors. There are many image analysis techniques available and the methods used depend on the requirements of the specific problem concerned. In many cases, image *segmentation* and *classification* algorithms are used to delineate different areas in an image into *thematic classes*. The resulting product is a *thematic map* of the study area. This thematic map can be combined with other databases of the test area for further analysis and utilization.

Remote Sensing Major Applications Area

Following are some major areas in which remote sensing is useful:

- Agriculture
- Forestry
- Weather
- Biodiversity
- Many more

As with its varied types of data, the specific applications of remote sensing are diverse as well. However, remote sensing is mainly conducted for image processing and interpretation. Image processing allows things like air photos and satellite images to be manipulated so they fi various project uses and/or to create maps. By using image interpretation in remote sensing an area can be studied without being physically present there.

The processing and interpretation of remote sensing images also have specific uses within various fields of study. In geology, for instance, remote sensing can be applied to analyze and map large, remote areas. Remote sensing interpretation also makes it easy for geologists in this case to identify an area's rock types, geomorphology, and changes from natural events such as a flood or landslide.

Remote sensing is also helpful in studying vegetation types. Interpretation of remote sensing images allows physical and biogeographers, ecologists, those studying agriculture, and foresters to easily detect what vegetation is present in certain areas, its growth potential, and sometimes what conditions are conducive to its being there.

Additionally, those studying urban and other land use applications are also concerned with remote sensing because it allows them to easily pick out which land uses are present in an area. This can then be used as data in city planning applications and the study of species habitat.

SUPARCO has over the years endeavoured to build competence and develop necessary infrastructure in the field of satellite remote sensing technology and its applications for undertaking nationally important projects for the federal ministries and provincial departments, public sector organizations, international agencies and the private sector. These efforts have borne fruit and the technology is now being extensively utilized for the socio-economic development and technological uplift of the country.

Applications of Remote Sensing Technology in Pakistan

Some of the areas in which satellite remote sensing technology has been applied with varying degree of impact in Pakistan are as follows:

- Agriculture
- Disaster monitoring and mitigation
- Surveying and urban planning
- Water resource management
- Environmental monitoring
- National spatial data infrastructure
- Infrastructure development planning and monitoring
- Mineral exploration
- Telecommunication
- Coastal eco-system monitoring

A few of the projects undertaken by SUPARCO in the recent past are highlighted below:

Agriculture – Crop Monitoring, Forecasting and Estimation

Crop monitoring, forecasting and estimation is being carried out around the year using satellite remote sensing and other technologies to fortify food security and allied disciplines in the country.

A pragmatic beginning was made by providing production statistics of three contiguous districts of cotton-wheat zone in Punjab and Sindh in 2005-06. The project area was expanded subsequently to 44 districts during 2006-07 and now entire country is being covered for monitoring, forecasting and estimation of wheat, cotton, rice, sugarcane, and maize crops throughout the year. A monthly agriculture bulletin is also being issued and can be accessed on the SUPARCO web site.

Disaster Monitoring and Mitigation

Remote sensing satellites can provide accurate and timely information of the disaster affected areas. Since the earthquake of 2005, SUPARCO has provided satellite imagery, damage assessment reports and other information to the disaster management and mitigation agencies. The turnaround time from a disaster occurring in Pakistan to the provision of imagery is less than two days. SUPARCO has also been involved in contingency planning in collaboration with UN agencies.

Watercourses Monitoring Under National Programme for Improvement of Watercourses (NPIW)

Project Monitoring Unit (PMU) of Govt of Sindh for the NPIW contacted SUPARCO for development of a system capable of real time monitoring and reporting of the field activities as well as repository of the irrigation network comprising 44,000 watercourses.

SUPARCO proposed an innovative solution which integrated satellite 3 imagery, GIS, GPS and cellular GSM/GPRS technologies for real time monitoring of the improvement work and repository of the irrigation network. This solution greatly facilitated accurate and timely monitoring as well as updation of records.

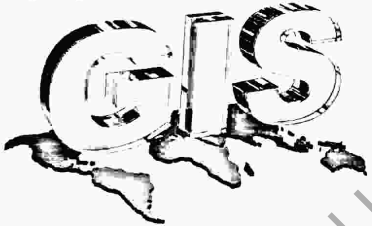
The system has also been used for inventorying of 58,000 watercourses in Punjab and 74,000 in KP.

Landuse Mapping of AJK

The Land Use Planning Cell, P&D Departments, Azad Jammu and Kashmir (AJK) requested SUPARCO for the provision of latest information on land use, urban sprawl mapping and infrastructure. The latest satellite imagery was acquired for land use and urban sprawl mapping. A digital elevation model was developed and used for elevation information. It was supplemented with extensive ground surveys by SUPARCO / AJK teams. A database with special reference to education and health facilities in the AJK has also been developed.

National Environmental Information Management System (NEIMS)

This project endeavours to develop a National Environmental Information Management System (NEIMS) in collaboration with the devolved Ministry of Environment, UNDP and other partners. Under this project, a web based application is being developed to monitor and analyse environmental changes using SRS and GIS technologies.



GIS – Geographic Information System

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships.

GIS technology is a crucial part of spatial data infrastructure, which the White House defines as "the technology, policies, standards, human resources, and related activities necessary to acquire, process, distribute, use, maintain, and preserve spatial data."

GIS can use any information that includes location. The location can be expressed in many different ways, such as latitude and longitude, address, or ZIP code.

Many different types of information can be compared and contrasted using GIS. The system can include data about people, such as population, income, or education level. It can include information about the landscape, such as the location of streams, different kinds of vegetation, and different kinds of soil. It can include information about the sites of factories, farms, and schools; or storm drains, roads, and electric power lines.

With GIS technology, people can compare the locations of different things in order to discover how they relate to each other. For example, using GIS, a single map could include sites that produce pollution, such as factories, and sites that are sensitive to pollution, such as wetlands and rivers. Such a map would help people determine where water supplies are most at risk.

Data Capture

Data Formats

GIS applications include both hardware and software systems. These applications may include cartographic data, photographic data, digital data, or data in spreadsheets.

Cartographic data are already in map form, and may include such information as the location of rivers, roads, hills, and valleys. Cartographic data may also include survey data, mapping information which can be directly entered into a GIS.

Photographic interpretation is a major part of GIS. Photo interpretation involves analyzing aerial photographs and assessing the features that appear.

Digital data can also be entered into GIS. An example of this kind of information is computer data collected by satellites that show land use—the location of farms, towns, and forests.

Remote sensing provides another tool that can be integrated into a GIS. Remote sensing includes imagery and other data collected from satellites, balloons, and drones.

Finally, GIS can also include data in table or spreadsheet form, such as population demographics. Demographics can range from age, income, and ethnicity to recent purchases and internet browsing preferences.

GIS technology allows all these different types of information, no matter their source or original format, to be overlaid on top of one another on a single map. GIS uses location as the key index variable to relate these seemingly unrelated data.

Putting information into GIS is called data capture. Data that are already in digital form, such as most tables and images taken by satellites, can simply be uploaded into GIS. Maps, however, must first be scanned, or converted to digital format.

The two major types of GIS file formats are raster and vector. Raster formats are grids of cells or pixels. Raster formats are useful for storing GIS data that vary, such as elevation or satellite imagery. Vector formats are polygons that use points (called nodes) and lines. Vector formats are useful for storing GIS data with firm borders, such as school districts or streets.

Spatial Relationships

GIS technology can be used to display spatial relationships and linear networks. Spatial relationships may display topography, such as agricultural fields and streams. They may also display land-use patterns, such as the location of parks and housing complexes.

Linear networks, sometimes called geometric networks, are often represented by roads, rivers, and public utility grids in a GIS. A line on a map may indicate a road or highway. With GIS layers, however, that road may indicate the boundary of a school district, public park, or other demographic or land-use area. Using diverse data capture, the linear network of a river may be mapped on a GIS to indicate the stream flow of different tributaries.

GIS must make the information from all the various maps and sources align, so they fit together on the same scale. A scale is the relationship between the distance on a map and the actual distance on Earth.

Often, GIS must manipulate data because different maps have different projections. A projection is the method of transferring information from Earth's curved surface to a flat piece of paper or computer screen. Different types of projections accomplish this task in different ways, but all result in some distortion. To transfer a curved, three-dimensional shape onto a flat surface inevitably requires stretching some parts and squeezing others.

A world map can show either the correct sizes of countries or their correct shapes, but it can't do both. GIS takes data from maps that were made using different projections and combines them so all the information can be displayed using one common projection.

GIS Maps

Once all of the desired data have been entered into a GIS system, they can be combined to produce a wide variety of individual maps, depending on which data layers are included. One of the most common uses of GIS technology involves comparing natural features with human activity.

For instance, GIS maps can display what manmade features are near certain natural features, such as which homes and businesses are in areas prone to flooding.

GIS technology also allows to "dig deep" in a specific area with many kinds of information. Maps of a single city or neighborhood can relate such information as average income, book sales, or voting patterns. Any GIS data layer can be added or subtracted to the same map.

GIS maps can be used to show information about numbers and density. For example, GIS can show how many doctors there are in a neighborhood compared with the area's population.

With GIS technology, researchers can also look at change over time. They can use satellite data to study topics such as the advance and retreat of ice cover in Polar Regions, and how that coverage has changed through time. A police precinct might study changes in crime data to help determine where to assign officers.

One important use of time-based GIS technology involves creating time-lapse photography that shows processes occurring over large areas and long periods of time. For example, data showing the movement of fluid in ocean or air currents help scientists better understand how moisture and heat energy move around the globe.

GIS technology sometimes allows users to access further information about specific areas on a map. A person can point to a spot on a digital map to find other information stored in the GIS about that location. For example, a user might click on a school to find how many students are enrolled, how many students there are per teacher, or what sports facilities the school has.

GIS systems are often used to produce three-dimensional images. This is useful, for example, to geologists studying earthquake faults.

GIS technology makes updating maps much easier than updating maps created manually. Updated data can simply be added to the existing GIS program. A new map can then be printed or displayed on screen. This skips the traditional process of drawing a map, which can be time-consuming and expensive.

Population Explosion & Population Planning

Definition of Population

Population is defined as all nationals present in, or temporarily absent from a country, and aliens permanently settled in a country. This indicator shows the number of people that usually live in an area. Growth rates are the annual changes in population resulting from births, deaths and net migration during the year. Total population includes the following: national armed forces stationed abroad; merchant seamen at sea; diplomatic personnel located abroad; civilian aliens resident in the country; displaced persons resident in the country. However, it excludes the following: foreign armed forces stationed in the country; foreign diplomatic personnel located in the country; civilian aliens temporarily in the country. Population projections are a common demographic tool. They provide a basis for other statistical projections, helping governments in their decision making. This indicator is measured in terms of annual growth rate and in thousands of people.

What is Over Population?

Overpopulation is a term that refers to a condition by which the population density enlarges to a limit that provokes the environmental deterioration, a remarkable decline in the quality of life, or a population collapse.

The term *population density* denotes the number of inhabitants dwelling in a specific area, for example: 100 inhabitants per square Kilometer.

In the past, infant and childhood deaths and short life spans used to limit population growth. In today's world, thanks to improved nutrition, sanitation, and medical care, more babies survive their first few years of life. The combination of a continuing high birth rate and a low death rate is creating a rapid population increase in many countries in Asia, Latin America and Africa and people generally lived longer. Over-population is defined as the condition of having more people than can live on the earth in comfort, happiness and health and still leave the world a fit place for future generations.

Overpopulation: Environmental and Social Problems

Human population is growing like never before. We are now adding *one billion* people to the planet every 12 years. That's about 220,000 per day.

The list of problems this is causing, or at least complicating, is a long one. It includes shortages of all our resources, war and social conflict, limits on personal freedom, overcrowding and the health and survival of other species.

Environmental Problems

- **Food:** one billion people, one out of every seven people alive, go to bed hungry.Every day, 25,000 people die of malnutrition and hunger-related diseases. Almost 18,000 of them are children under 5 years old. Food production and distribution could catch up if our population stopped growing and dropped to a sustainable level.
- **Water Shortages:** About one billion people lack access to sufficient water for consumption, agriculture and sanitation. Aquifers are being depleted faster than they can be replenished. Melting glaciers threaten the water supply for billions. According to UN-Water, 75% of planet Earth is covered in water. 97.5% of that is ocean and 2.5% is freshwater. 70% of freshwater is divided into glaciers and ice caps and the remaining 30% into land surface water, such as rivers, lakes, ponds and groundwater. Most of the freshwater resources are either unreachable or too polluted, leaving less than 1% of the

worlds freshwater, or about 0.003% of all water on Earth, readily accessible for direct human use. According to the Global Outlook for Water Resources to the Year 2025, it is estimated that by 2025, more than half of the world population will be facing water-based vulnerability and human demand for water will account for 70% of all available freshwater. Furthermore, a report in November 2009 by the 2030 Water Resources Group suggests that by 2030, in some developing regions in the world, water demand will exceed supply by 50% and a report jointly produced by more than two dozen U.N. bodies states that, "By 2030, nearly half of the world's people will be living in areas of acute water shortage." The planet is in the midst of what the United Nations is calling a "Global Water Crisis." Freshwater is the most fundamental finite resource with no substitutes for most uses, yet we are consuming fresh water at least 10 times faster than it is being replenished in regions of northern Africa, the Middle East, India, Pakistan, China, and the U.S.. According to the World Resources Institute, "Freshwater ecosystems – the diverse communities found in lakes, rivers, and wetlands – may be the most endangered of all. Some 34 percent of fish species, mostly from fresh water, are threatened with extinction, according to the latest tally of the World Conservation Union (IUCN), which tracks threats to the world's biodiversity. Freshwater ecosystems have lost a greater proportion of their species and habitat than ecosystems on land or in the oceans; in addition, they are probably in greater danger of further losses from dams, pollution, overfishing, and other threats. In extent, freshwater ecosystems are quite limited, covering only about 1 percent of the Earth's surface. Yet, they are highly diverse and contain a disproportionately large number of the world's species." As human populations grow, so will the problem of clean freshwater availability

- **Air quality**: In many regions of the country, childhood asthma rates have risen dramatically in the past 20 years. The problems are not limited to the industrialized countries with their automobiles and factories. Children in undeveloped countries, where people depend on burning wood and dung for their heat and cooking, are also at risk.
- **Oil and gas** are the underpinnings of what is, historically-speaking, the extremely cheap and fast transportation that today's huge population depends on. Imagine how we could feed and supply our huge cities if all the hauling was done in horse-drawn carts and sailing ships. Yet there is a finite amount of these fossil fuels in the Earth, and we have already extracted the easy-pickings in much of the world. The concept "Peak Oil" means that after some year, perhaps between 2005 and 2020, world oil production will max out and then start to decline.
- **Other Fuel:** Half the World's population relies on **burning wood** and dung for cooking and for heating. More and more people live in these regions and have to travel further each day to collect wood, and are often exposed to hardship and danger.
- **The World's forests** are another resource that is strained by our growing population. Not only are they a source of fuel and building material, recent research has focused on forests' ability to sequester greenhouse gases and protect us from global warming

Social Problems

- **Overcrowding.** It's a common observation that people in small towns are friendlier than people in cities. However, that's just a hunch for most of us. One recent study from U.C. Irvine found that less densely packed people **are** friendlier towards their neighbors. One

specific finding was, "For every 10 percent decrease in population density, the likelihood of residents talking to their neighbors at least once a week jumps by 10 percent. And involvement in hobby-oriented clubs increases even more significantly -- by 15 percent for every 10 percent decline in density."

- **Conflicts and Wars**: Some of the most brutal and persistent conflicts and full-out wars of the past decades include the stresses of overpopulation and conflict over resources.
- **Health and Population density**: sometimes viruses spread faster in denser populations, which enables deadly mutations to continue.
- **Lower Life Expectancy in the Fastest Growing Countries** According to a Harvard study, "Over the next forty years, nearly all (97%) of the 2.3 billion projected increase will be in the less developed regions, with nearly half (49%) in Africa." Already strained with relentless population explosion, many developing countries, such as in Sub Saharan Africa and Southern Asia, will experience a degradation of their quality and length of life as they face increasing difficulties to supply water, food, energy and housing to their growing populations, which will have major repercussions for public health, security measures and economic growth. These situations are especially dire for populations in Uganda, Nigeria, and Bangladesh, which will double and, in some cases, even triple over the next 40 years.
- **Increased Emergence of New Epidemics and Pandemics:** A WHO report shows that environmental degradation, combined with the growth in world population, is a major cause of the rapid increase in human diseases, which contributes to the malnutrition of 3.7 billion people worldwide, making them more susceptible to disease. According to the World Health Organization, "Every three seconds a young child dies - in most cases from an infectious disease. In some countries, one in five children die before their fifth birthday. Every day 3 000 people die from malaria - three out of four of them children. Every year 1.5 million people die from tuberculosis and another eight million are newly infected." Overpopulation exacerbates many social and environmental factors, including overcrowded living conditions, pollution, malnutrition and inadequate or non-existent health care, which wreak havoc on the poor and increase their likelihood of being exposed to infections diseases.
- **Increased Habitat Loss:** Human overpopulation is a major driving force behind the loss of ecosystems, such as rainforests, coral reefs, wetlands and Arctic ice. Rainforests once covered 14% of the Earth's land surface, now they cover a bare 6% and experts estimate that the last remaining rainforests could be consumed in less than 40 years and certainly by the end of the century at the current rate of deforestation. Due mainly to warming temperatures, acidifying oceans and pollution, close to 30% of the ocean's reefs have already vanished since 1980, including half of the reefs in the Caribbean and 90% of the Philippines' coral reefs, and scientists forecast that Australia's Great Barrier Reef may be dead by the year 2050 and all coral reefs could be gone by the end of the century. Furthermore, the area of permanent ice cover is now declining at a rate of 11.5% per decade, relative to the 1979 to 2000 average. If this trend continues, summers in the Arctic could become ice-free in as few as 4 years or in the next 30 years. Wetlands are increasingly under threat in the United States, but also all over the world. In the U.S., less than half of original wetlands remain with 53% being lost, which is about 104 million acres. In Europe, between 60% and 70% of wetlands have been completely destroyed. As

human populations continue to grow, so will our footprint on the interconnected ecological infrastructures of life.

- **Elevated Crime Rate:** As human overpopulation drives resources and basic necessities such as food and water, to become scarcer, there will be increased competitiveness for these resources which leads to elevated crime rates due to drug cartels and theft by people in order to survive. As Aisha Tariq of the Pakistan Times states, "It has been observed that the countries which have balanced population, crime rate is very low in such regions. When people are not provided with the basic necessities, it elevates crime rate."

Family Planning

Family planning, by definition, is deciding the number and spacing of your children through the use of contraception; such as abstinence, natural planning, or hormonal birth control.

Family planning refers to practices that help couples to avoid unwanted births, to bring about wanted births, to regulate the interval between pregnancies, to control the time at which births occur in relation to age of parents and to determine the number of children they wish to have in their family. More specifically, as defined by the World Health Organization, family planning allows individuals and couples to anticipate and attain their desired number of children and the spacing and timing of their births. It is achieved through use of contraceptive methods and the treatment of involuntary fertility.

Birth Control

There are many types of contraceptives available today to allow individuals to choose the type of birth control that best fits their lifestyle and budget.

This chart showing the relative effectiveness of each method may be helpful when making your decision.

Contraceptive methods can be roughly divided into five types:

- Hormonal methods
- Barrier methods (chemical and physical)
- Intrauterine Device (IUD) (Copper & Hormonal)
- Natural Methods
- Emergency Contraception

Who provides family planning / contraceptives?

It is important that family planning is widely available and easily accessible through midwives and other trained health workers to anyone who is sexually active, including adolescents. Midwives are trained to provide (where authorized) locally available and culturally acceptable contraceptive methods. Other trained health workers, for example community health workers, also provide counseling and some family planning methods, for example pills and condoms. For methods such as sterilization, women and men need to be referred to a clinician.

Contraceptive use

Contraceptive use has increased in many parts of the world, especially in Asia and Latin America, but continues to be low in sub-Saharan Africa. Globally, use of modern contraception has risen slightly, from 54% in 1990 to 57.4% in 2015. Regionally, the proportion of women aged 15–49 reporting use of a modern contraceptive method has risen minimally or plateaued between 2008 and 2015. In Africa it went from 23.6% to 28.5%, in Asia it has risen slightly from 60.9% to 61.8%, and in Latin America and the Caribbean it has remained stable at 66.7%.

Use of contraception by men makes up a relatively small subset of the above prevalence rates. The modern contraceptive methods for men are limited to male condoms and sterilization (vasectomy).

Global unmet need for contraception

214 million women of reproductive age in developing countries who want to avoid pregnancy are not using a modern contraceptive method. Reasons for this include:

- limited choice of methods;
- limited access to contraception, particularly among young people, poorer segments of populations, or unmarried people;
- fear or experience of side-effects;
- cultural or religious opposition;
- poor quality of available services;
- users and providers bias
- gender-based barriers.

The unmet need for contraception remains too high. This inequity is fuelled by both a growing population, and a shortage of family planning services. In Africa, 24.2% of women of reproductive age have an unmet need for modern contraception. In Asia, and Latin America and the Caribbean – regions with relatively high contraceptive prevalence – the levels of unmet need are 10.2 % and 10.7%, respectively (Trends in Contraception Worldwide 2015, UNDESA).

Contraceptive methods

Modern methods

Method	Description	How it works	Comments
Combined oral contraceptives (COCs) or "the pill"	Contains two hormones (estrogen and progestogen)	Prevents the release of eggs from the ovaries (ovulation)	Reduces risk of endometrial and ovarian cancer
Progestogen-only pills (POPs) or "the minipill"	Contains only progestogen hormone, not estrogen	Thickens cervical mucous to block sperm and egg from meeting and prevents ovulation	Can be used while breastfeeding; must be taken at the same time each day
Implants	Small, flexible rods or capsules placed under the skin of the upper arm; contains progestogen hormone only	Thickens cervical mucous to block sperm and egg from meeting and prevents ovulation	Health-care provider must insert and remove; can be used for 3–5 years depending on implant; irregular vaginal bleeding common but not harmful
Progestogen only injectables	Injected into the muscle or under the skin every 2 or 3 months, depending on product	Thickens cervical mucous to block sperm and egg from meeting and prevents ovulation	Delayed return to fertility (about 1–4 months on the average) after use; irregular vaginal bleeding common, but not harmful

Monthly injectables or combined injectable contraceptives (CIC)	Injected monthly into the muscle, contains estrogen and progestogen	Prevents the release of eggs from the ovaries (ovulation)	Irregular vaginal bleeding common, but not harmful
Combined contraceptive patch and combined contraceptive vaginal ring (CVR)	Continuously releases 2 hormones – a progestin and an estrogen- directly through the skin (patch) or from the ring	Prevents the release of eggs from the ovaries (ovulation)	The Patch and the CVR provide a comparable safety and pharmacokinetic profile to COCs with similar hormone formulations.
Intrauterine device (IUD): copper containing	Small flexible plastic device containing copper sleeves or wire that is inserted into the uterus	Copper component damages sperm and prevents it from meeting the egg	Longer and heavier periods during first months of use are common but not harmful; can also be used as emergency contraception
Intrauterine device (IUD) levonorgestrel	A T-shaped plastic device inserted into the uterus that steadily releases small amounts of levonorgestrel each day	Thickens cervical mucous to block sperm and egg from meeting	Decreases amount of blood lost with menstruation over time; Reduces menstrual cramps and symptoms of endometriosis; amenorrhea (no menstrual bleeding) in a group of users
Male condoms	Sheaths or coverings that fit over a man's erect penis	Forms a barrier to prevent sperm and egg from meeting	Also protects against sexually transmitted infections, including HIV
Female condoms	Sheaths, or linings, that fit loosely inside a woman's vagina, made of thin, transparent, soft plastic film	Forms a barrier to prevent sperm and egg from meeting	Also protects against sexually transmitted infections, including HIV
Male sterilization (vasectomy)	Permanent contraception to block or cut the vas deferens tubes that carry sperm from the testicles	Keeps sperm out of ejaculated semen	3 months delay in taking effect while stored sperm is still present; does not affect male sexual performance;

			Voluntary and informed choice is essential
Female sterilization (tubal ligation)	Permanent contraception to block or cut the fallopian tubes	Eggs are blocked from meeting sperm	Voluntary and informed choice is essential
Lactational amenorrhea method (LAM)	Temporary contraception for new mothers whose monthly bleeding has not returned, requires exclusive or full breastfeeding day and night of an infant less than 6 months old	Prevents the release of eggs from the ovaries (ovulation)	A temporary family planning method based on the natural effect of breastfeeding on fertility
Emergency contraception pills (ulipristal acetate 30 mg or levonorgestrel 1.5 mg)	Pills taken to prevent pregnancy up to 5 days after unprotected sex	Delays ovulation	Does not disrupt an already existing pregnancy
Standard Days Method or SDM	Women track their fertile periods (usually days 8 to 19 of each 26 to 32 day cycle) using cycle beads or other aids	Prevents pregnancy by avoiding unprotected vaginal sex during most fertile days.	Can be used to identify fertile days by both women who want to become pregnant and women who want to avoid pregnancy. Correct, consistent use requires partner cooperation.
Basal Body Temperature (BBT) Method	Woman takes her body temperature at the same time each morning before getting out of bed observing for an increase of 0.2 to 0.5 degrees C.	Prevents pregnancy by avoiding unprotected vaginal sex during fertile days	If the BBT has risen and has stayed higher for 3 full days, ovulation has occurred and the fertile period has passed. Sex can resume on the 4th day until her next monthly bleeding.
TwoDay Method	Women track their fertile periods by	Prevents pregnancy by avoiding	Difficult to use if a woman has a vaginal

	observing presence of cervical mucus (if any type color or consistency)	unprotected vaginal sex during most fertile days.	infection or another condition that changes cervical mucus. Unprotected coitus may be resumed after 2 consecutive dry days (or without secretions)
Sympto-thermal Method	Women track their fertile periods by observing changes in the cervical mucus (clear texture), body temperature (slight increase) and consistency of the cervix (softening).	Prevents pregnancy by avoiding unprotected vaginal sex during most fertile	May have to be used with caution after an abortion, around menarche or menopause, and in conditions which may increase body temperature.

Traditional methods

Method	Description	How it works	Comments
Calendar method or rhythm method	Women monitor their pattern of menstrual cycle over 6 months, subtracts 18 from shortest cycle length (estimated 1st fertile day) and subtracts 11 from longest cycle length (estimated last fertile day)	The couple prevents pregnancy by avoiding unprotected vaginal sex during the 1st and last estimated fertile days, by abstaining or using a condom.	May need to delay or use with caution when using drugs (such as anxiolytics, antidepressants, NSAIDS, or certain antibiotics) which may affect timing of ovulation.
Withdrawal (coitus interruptus)	Man withdraws his penis from his partner's vagina, and ejaculates outside the vagina, keeping semen away from her external genitalia	Tries to keep sperm out of the woman's body, preventing fertilization	One of the least effective methods, because proper timing of withdrawal is often difficult to determine, leading to the risk of ejaculating while inside the vagina

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Food Science

What is Food Science?

Food Science is the study of the physical, biological, (including microbiological), and emical makeup of food. Food Scientists and Technologists apply many scientific disciplines, luding Chemistry, Engineering, Microbiology, Epidemiology, Nutrition, and Molecular iology to the study of food to improve the safety, nutrition, wholesomeness, and availability of od. Depending on their area of specialization, Food Scientists develop ways to process, serve, package, and/or store food, according to industry and government specifications and gulations. Consumers seldom think of the vast array of foods and the research and development at has resulted in the means to deliver tasty, nutritious, safe, and convenient foods.

Human Nutrition affects the health and survival of the human body. Human beings quire food to grow, reproduce, and maintain good health. Without food, our bodies could not ay warm, build or repair tissue, or maintain a heartbeat. Eating the right foods can help us avoid rtain diseases or recover faster when illness occurs. These and other important functions are ueled by chemical substances in our food called nutrients

Balanced Diet'

Q: Write a comprehensive note on Balanced Diet' (CSS 2018)

Balance diet and Energy Requirement (CSS 1993, 1994, 2002, 2007, 2008, 2012)

The human body requires various types of nutrients in order to keep the body healthy and fit. These nutrients should be taken appropriately in our diet. The diet that we follow should be balanced. Balanced diet is a diet, which provides all the nutrients needed by the body in correct proportions.

This means that it should contain all the types of nutrients in the required quantities. Each meal should contain sources of carbohydrates (such as cereals), proteins (such as pulses), fats (such as cooking oil), vitamins and minerals (such as variety of vegetables).

Some of the common foods and their composition are given below:

Food	Carbohydrate	Fat	Protein
Bread (*Roti*)	52%	3%	9%
Rice (*cooked*)	23%	0.1%	2.2%
Banana	20%	0.5%	1.0%
Potato	19%	0.1%	2%
Peas	16.7%	0.5%	5.2%
Apples	12.8%	0.5%	0.3%
Cabbage	5.5%	0.3%	1.2%
Spinach (*Palak, Saag*)	3.2%	0.3%	1.6%
Eggs	0.7%	12%	13%
Milk	4%	4%	4%
Butter	0.4%	81%	0.6%
Cheese	2%	32%	25%

Food	Carbohydrate	Fat	Protein
Meat	0	30%	22%
Chicken	0	11%	20%
Fish	0	0.4%	17%

Recommended daily allowances of energy, proteins and fats

Group	Body Wt in kg	Net Energy in k Cal	Protein in g	Fat in g
Adult Man	60	2875	60	20
Woman	50	2225	50	20
13-15 yrs Boy	47-48	2450	70	22
Girl	46-47	2060	55	22

Balanced diets of moderately active adult

Food	Recommended amounts (g per day)	
	Adult Man	Adult Woman
Cereals (*rice/wheat*)	520	440
Pulses	50	45
Meat/Fish	30	30
Egg	1	1
Milk	200	150
Oil/fats	45	25
Sugar/molasses	35	20
Roots and tubers (*potato, etc.*)	60	50
Green leafy vegetables (*spinach, etc.*)	40	100
Other vegetables (*cauliflower, etc.*)	70	40

Components of Diet

The basic components of a healthy diet include the right amount of:

- **Protein** (found in fish, meat, poultry, dairy products, eggs, nuts, and beans)
- **Fat** (found in animal and dairy products, nuts, and oils)
- **Carbohydrates** (found in fruits, vegetables, pasta, rice, grains, beans and other legumes and sweets)
- **Vitamins** (such as vitamins A, B, C, D, E, and K)
- **Minerals** (such as calcium, potassium, and iron)
- **Water**

Carbohydrates

Carbohydrates provide fuel for the body in the form of glucose. **Glucose is a sugar that is the primary source of energy for all of the body's cells.** Adults should get about

45%-65% of their calories from carbohydrates.

Protein

Proteins are nutrients that are essential to the building, maintenance, and repair of body tissue such as the skin, the internal organs, and muscle. Proteins are made up of **amino acids** there are 22 in all. **The body can make 14; the other eight (called essential amino acids) can only be obtained from what we eat.** Proteins are found in all types of food, but **only fish, meat, poultry, eggs, cheese, and other foods from animal sources contain complete proteins, meaning they provide the eight essential amino acids.**

Fat

Fat is made up of compounds called fatty acids or lipids. Depending on their chemical structure, these fatty acids are called **monounsaturated, polyunsaturated, saturated, or trans fats.**

Vitamins

Vitamins help with chemical reactions in the body. In general, vitamins must come from the diet: the body doesn't make them. **There are 13 vitamins essential to the body. They are divided into two categories: water-soluble** (vitamin C and all the B vitamins) **and fat-soluble** (vitamins A, D, E, and K). The fat-soluble vitamins are more easily stored by the body. Thus, you do not need large amounts of these vitamins since excess amounts can be toxic and cause a variety of problems. Because the water-soluble vitamins aren't stored for long in the body, we must consume them daily. And, although taking large doses of these vitamins isn't necessarily dangerous, it may be wasteful as the body eliminates the excess water-soluble vitamins in the urine.

Minerals

Minerals, like vitamins, must come from the diet; the body doesn't make them. Many minerals are vital to the proper function of the body and must be taken in relatively large amounts (such as calcium, potassium, and iron.) Others, like trace minerals (zinc, selenium, and copper), are only needed in small amounts to maintain good health

Water

Water is the most plentiful substance in the body, accounting for 55%-65% of body weight, but because the body can't store water, we must constantly replenish it.

Carbohydrates

Q: **Define 'Carbohydrate?'. Describe different steps to digest these in the human body** (CSS-2018)

Definition

Carbohydrates are one of the main dietary components. This category of foods include sugars, starches, and fiber.

Alternative Names

Starches; Simple sugars; Sugars, Complex carbohydrates; Diet - carbohydrates; Simple carbohydrates

Carbohydrates are the human body's key source of energy, providing 4 calories of energy per gram. When carbohydrates are broken down by the body, the sugar glucose is produce glucose is critical to help maintain tissue protein, metabolize fat, and fuel the central nervous system. Glucose is absorbed into the bloodstream through the intestinal wall. Some of th glucose goes straight to work in our brain cells and red blood cells, while the rest makes its way to the liver and muscles, where it is stored as glycogen (animal starch), and to fat cells, where it i stored as fat. Glycogen is the body's auxiliary energy source, tapped and converted back into glucose when we need more energy

Function

The primary function of carbohydrates is to provide energy for the body, especially th brain and the nervous system. An enzyme called amylase helps break down carbohydrates into glucose (blood sugar), which is used for energy by the body.

Food Sources

Carbohydrates are available in: Fruits, Milk and milk products, Honey and Vegetables etc

Classification

There are a variety of interrelated classification schemes. The most useful classification scheme divides the carbohydrates into groups according to the number of individual simple sugar units. **Monosaccharides** contain a single unit; **disaccharides** contain two sugar units; and **polysaccharides** contain many sugar units as in polymers - most contain glucose as the monosaccharide unit.

	Carbohydrates	
Monosaccharides	**Disaccharides**	**Polysaccharides**
Glucose	Sucrose	Starch
Galactose	Maltose	Glycogen
Fructose	Lactose	Cellulose
Ribose		
Glyceraldehyde		

Monosaccharaides

Three common sugars share the same molecular formula: $C_6H_{12}O_6$. Because of their si carbon atoms, each is a **hexose**.

They are:

- **glucose**, "blood sugar", the immediate source of energy for cellular respiration
- **Galactose**, a sugar in milk (and yogurt), and
- **fructose**, a sugar found in honey.

Glucose, galactose, and fructose are "single" sugars or **monosaccharaides**. Tw

monosaccharaides can be linked together to form a "double" sugar or **disaccharide**.

Disaccharides

Three common disaccharides:

- **sucrose** — common table sugar = glucose + fructose
- **lactose** — major sugar in milk = glucose + galactose
- **maltose** — product of starch digestion = glucose + glucose

Although the process of linking the two monomers is rather complex, the end result in each case is the loss of a hydrogen atom (H) from one of the monosaccharaides and a hydroxyl group (OH) from the other. The resulting linkage between the sugars is called a **glycosidic bond**. The molecular formula of each of these disaccharides is

$$C_{12}H_{22}O_{11} = 2\ C_6H_{12}O_6 - H_2O$$

Polysaccharides

Starches

Starches are insoluble in water and thus can serve as storage depots of glucose. Plants convert excess glucose into starch for storage.

Glycogen

Animals store excess glucose by polymerizing it to form **glycogen**. Glycogen is broken back down into glucose when energy is needed (a process called glycogenolysis)

Cellulose

Cellulose is probably the single most abundant organic molecule in the biosphere. It is the major structural material of which plants are made. Wood is largely cellulose while cotton and paper are almost pure cellulose.

Chitin

Chitin (C8H13O5N)n is a long-chain polymer, and is found in many places throughout the natural world. It is the main component of the cell walls of fungi In terms of structure; chitin may be compared to the polysaccharide cellulose and, in terms of function, to the protein keratin. It is a polysaccharide; it is constructed from units of acetylglucosamine (more completely, N-acetyl-D-glucos-2-amine). In effect chitin may be described as cellulose with one hydroxyl group on each monomer replaced by an acetylamine group. This allows for increased hydrogen bonding between adjacent polymers, giving the polymer increased strength. It is the second most abundant biopolymer on earth, found especially in insects and fungi. When deacetylated it is called chitosan. Chitosan is prepared from chitin by deacetylation.

Diabetes Insipidus vs Diabetes Mellitus

Diabetes mellitus is characterized by high levels of sugar in the blood while diabetes insipidus is a disease where kidneys are unable to conserve water. **Diabetes insipidus** (DI) is a rare disease while diabetes mellitus is very common; "diabetes" in general usage refers to diabetes mellitus. The causes, symptoms, treatment and prognosis for both diseases are different.

	Diabetes Insipidus	Diabetes Mellitus
Characteristic symptoms:	Excessive thirst, excess volume of severely diluted urine	High blood sugar, excessive urination, increased thirst, increased hunger.
Incidence:	3 in 100,000 people	7.7 per 1000 people
Causes	Deficiency of ADH. Brain tumor,	Type 1 - Autoimmune Disease;

	head injury, medication such as lithium, genetics	Type 2 - Genetics, lifestyle infection
Treatment:	Typically desmopressin (nasal spray) or IM, IV hypertonic saline solution (3% or 5%). Thiazide diuretics	Insulin and lifestyle management
Prognosis:	No effect on life expectancy	Up to 10 years shorter life expectancy
Curable	No	No

Proteins

Proteins are the chief body builders of the body. They are complex molecules made up of carbon, hydrogen, oxygen and nitrogen (sometimes sulphur and phosphorus). Proteins are used to synthesize enzymes (e.g., pepsin, trypsin), hormones (e.g., insulin, adrenaline), carrier proteins (e.g. Haemoglobin), contractile proteins (e.g., myosin, actin), structural proteins (e.g., collagen) and protective proteins (antibodies). They also form skin pigments like melanin and nucleic acids of the genetic material, DNA and RNA - purines and pyrimidines.

Normal protein requirement of an adult is 1g/kg of the body weight. However, growing children, pregnant and nursing mothers need more proteins.

Sources

Sources of Proteins are of both animal and plant origin. Some of the common sources are groundnuts, beans, whole cereals, pulses, among plants and fish, egg, meat, milk, cheese among animal products

Composition of proteins

The proteins are polymers made of monomers called the **amino acids.**

Amino acids are organic compounds made of carbon, hydrogen, oxygen, nitrogen, and (in some cases) sulfur bonded in characteristic formations. Strings of amino acids make up proteins, of which there are countless varieties. Of the 20 amino acids required for manufacturing the proteins the human body needs, the body itself produces only 12, meaning that we have to meet our requirements for the other eight through nutrition. This is just one example of the importance of amino acids in the functioning of life

When proteins are digested or broken down, amino acids are left. The human body needs a number of amino acids to:

- Break down food
- Grow
- Repair body tissue
- Perform many other body functions

Amino acids are classified into three groups:

- Essential amino acids
- Nonessential amino acids
- Conditional amino acids

Essential amino acids

- Essential amino acids cannot be made by the body. As a result, they must come from food.
- The nine essential amino acids are: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

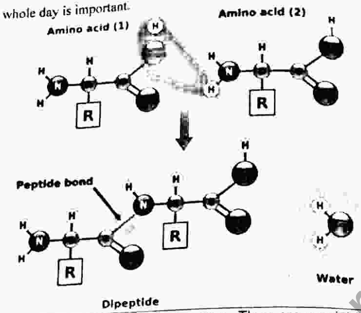
Nonessential amino acids

- "Nonessential" means that our bodies produce an amino acid, even if we don't get it from the food we eat.
- They include: alanine, asparagine, aspartic acid, and glutamic acid.

Conditional amino acids

- Conditional amino acids are usually not essential, except in times of illness and stress.
- They include: arginine, cysteine, glutamine, tyrosine, glycine, ornithine, proline, and serine.

You do not need to eat essential and nonessential amino acids at every meal, but getting a balance of them over the whole day is important.



Amino acids are the basis of all life processes. They are crucial in terms of metabolism and transport/storage of nutrients, such as water, minerals, carbs, etc. The lack of these amino acids can result in high-cholesterol, erectile dysfunction, insomnia, and much more. These acids can be maintained by eating an adequate amount of red meat, fish, and dairy products.

Difference between Essential Amino Acids and Non Essential Amino Acids

Essential Amino Acids	Non-Essential Amino Acids
Cannot be synthesized in the animal body	Can be synthesized in the animal body
It should be obtained from the diet (*therefore called as essential amino acids*)	It can be synthesized in the body therefore called as non-essential amino acids
9 essential amino acids are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.	Non-essential amino acids are alanine, asparagine, aspartic acid, and glutamic acid.

Classification of Proteins

Simple Proteins

A simple protein is a protein that yields only amino acids when hydrolized. Examples of simple proteins include peptones, peptides, albumins (egg albumin, serum albumin, lact albumin), globulin (tissue globulin, serum globulin), gliadins (wheat gliadin, hordein, barley), prolamine (fliadin from wheat, zein from corn), albuminoids (keratin from skin, hair and fingernails or toenails, collagen), histones, and protamines.

Keratin

Keratin, the structural protein of epithelial cells in the outermost layers of the skin, has been isolated from hair, nails, hoofs, and feathers.

Collagen

Collagen is the structural protein of bones, tendons, ligaments, and skin. For many years collagen was considered to be insoluble in water.

Elastin

Elastin is the protein in the extracellular matrix surrounding the skin, organs and connective tissues that gives these materials their strength and elasticity -- it is the "rubber band" that causes our skin and other organs to maintain their shape and "snap back" if they are stretched.

Conjugate proteins

Conjugate proteins are those which contain a non-amino acid component in addition to the amino acids. This non-amino acid component is called the prosthetic group.

- **Glycoprotein** *(with carbohydrate as the prosthetic group)*
- **Phosphoprotein** *(with phosphate as the prosthetic group)*
- **Lipoprotein** *(with lipid as the prosthetic group).*

Derived Proteins

These are not naturally occurring proteins and are obtained from simple proteins by the action of enzymes and chemical agents.

Examples: peptones, peptides, proteoses etc.

Protein Intake

Experts recommend that protein intake make up only 10 percent of our daily calorie intake. Some people, especially in the United States and other developed countries, consume more protein than the body needs. Because extra amino acids cannot be stored for later use, the body destroys these amino acids and excretes their by-products. Alternatively, deficiencies in protein consumption, seen in the diets of people in some developing nations, may result in health problems. Marasmus and kwashiorkor, both life-threatening conditions, are the two most common forms of protein malnutrition.

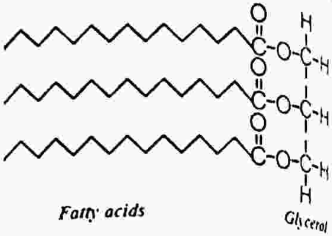
The best way to get protein is from foods that have what is called "complete protein." This means they have all the essential amino acids. Most complete protein foods come from animals, such as beef, fish, chicken and eggs. Vegetarians can meet their protein needs either through supplements, or combining "incomplete proteins," such as legumes and nuts.

Functions of proteins

1. Proteins build new tissues of the body.
2. They maintain and replace damaged tissues.
3. They carry out regulating activities as enzymes and hormones.
4. They are protective as antibodies.
5. They help in other important activities such as movement of skeletal muscles, transport of oxygen, pigmentation of skin, etc.

LIPIDS (Fats & Oils)

Lipid is the collective name for fats, oils, waxes and fat-like molecules (such as steroids, found in the body **Lipids** consisting of three molecules of fatty acids covalently bonded to one molecule of **glycerol** are termed **triglycerides** (*or triacylglycerols*), but are more commonly known as ***fats and oils***.



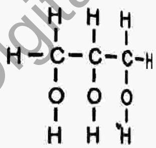
These molecules are the ultimate type of energy storage molecule because of their high calorific value and the fact that they can also thermally protect an animal's body from loss of heat in cold climates.

However, they are found in both animals and plants and constitute an important part of the human diet. The division into fats and oils is arbitrary and depends on the physical state of these molecules at room temperature. Those molecules that are usually solid at room temperature (plant or animal) are termed *oils*. These latter are are termed *fats*, while those that are liquids at room temperature are termed *oils*. These latter are usually found in plants, but fish also store liquid forms of triglycerides (fish oils).

Fatty acids

Fatty acids are also organic compounds. Each fatty acid has a **carboxylic acid** (-COOH) group. Some fatty acids are saturated. These means all carbon-carbon bonds are single covalent bonds. Other fatty acids are unsaturated. This means that while most carbon-carbon bonds are single covalent bonds, some are double bonds.

Triglycerides



Fats and *oils* are made from two kinds of molecules: *glycerol* (*a type of alcohol with a hydroxyl group on each of its three carbons*) and three *fatty acids* joined by dehydration synthesis. Since there are three fatty acids attached, these are known as *triglycerides*. Triglycerides are the chemical form in which most fat exists in food as well as in the body. They're also present in blood plasma and, in association with cholesterol, form the plasma lipids.

Sources of fats

The common sources of fats are butter, ghee, cheese, meat, egg yolk, milk, nuts, etc

Classification of fats

There are two types of fat - *saturated* and *unsaturated*. *Saturated fats* do not have double bonds and are solids at room temperature. Whereas, *unsaturated fats* have one or more double bonds and are liquids at room temperature. Butter, ghee, etc. are saturated fats and oils are unsaturated fats. High intake of saturated fats increases blood cholesterol level that can lead to coronary disorders and high blood pressure. Thus people who have a sedentary lifestyle such as old people should reduce the intake of saturated fats. However people involved in heavy labour, fat intake should be more, as their energy requirement is high.

Depending on the dietary *requirements, fats are of two kinds - essential and non-essential*. Essential fats are those that are not synthesized by the body and have to be included in the diet. For e.g., linoleic acid, linolenic acid, arachidonic acid, etc. Non-essential fats are those that are synthesized by the body and are not necessary in the diet. For e.g., glycine.

Trans Fat

Trans fatty acids (commonly termed trans fats) are a type of unsaturated fat (and may be monounsaturated or polyunsaturated). Trans fats occur naturally, in small quantities, in meat and dairy products from ruminants Most trans fats consumed today, however, are industrially created as a side effect of partial hydrogenation of plant oils. Partial hydrogenation changes a fat's molecular structure (raising its melting point and reducing rancidity) but this process also results in a proportion of the changed fat becoming trans-fat. Unlike other fats, trans fats are neither required nor beneficial for health. Eating trans-fat increases the risk of coronary heart disease. For these reasons, health authorities worldwide recommend that consumption of trans fat be reduced to trace amounts. Trans fats from partially hydrogenated oils are generally considered to be more of a health risk than those occurring naturally.

Q: What is Cholesterol? Discuss its importance, normal blood level and dangers of elevated levels with reference to the health and disease in humans.
(CSS-2016)

Cholesterol

Cholesterol is a lipid (fat) which is produced by the liver. Cholesterol is vital for normal body function. Every cell in our body has cholesterol in its outer layer.
Cholesterol is a waxy steroid and is transported in the blood plasma of all animals. It is the main sterol synthesized by animals - small amounts are also synthesized in plants and fungi. A sterol is a steroid sub-group.

Functions of cholesterol

- It builds and maintains cell membranes (outer layer), it prevents crystallization of hydrocarbons in the membrane
- It is essential for determining which molecules can pass into the cell and which cannot (cell membrane permeability)
- It is involved in the production of sex hormones (androgens and estrogens)
- It is essential for the production of hormones released by the adrenal glands (cortisol, corticosterone, aldosterone, and others)
- It aids in the production of bile
- It converts sunshine to vitamin D. Scientists from the Rockefeller University were surprised to find that taking vitamin D supplements do not seem to reduce the risk of cholesterol-related cardiovascular disease.
- It is important for the metabolism of fat soluble vitamins, including vitamins A, D, E. and K
- It insulates nerve fibers

Three main types of lipoproteins

Cholesterol is carried in the blood by molecules called lipoproteins. A lipoprotein is any complex or compound containing both lipid (fat) and protein. The three main types are:

- **LDL (low density lipoprotein)** - people often refer to it as *bad cholesterol*. LDL carries cholesterol from the liver to cells. If too much is carried, too much for the cells to use, there can be a harmful buildup of LDL. This lipoprotein can increase the risk of arterial disease if levels rise too high. Most human blood contains approximately 70% LDL - this may vary, depending on the person.

- **HDL (high density lipoprotein)** - people often refer to it as *good cholesterol*. Experts say HDL prevents arterial disease. HDL does the opposite of LDL - HDL takes cholesterol away from the cells and back to the liver. In the liver it is either broken down or expelled from the body as waste.
- **Triglycerides** - these are the chemical forms in which most fat exists in the body, as well as in food. They are present in blood plasma. Triglycerides, in association with cholesterol, form the plasma lipids (blood fat). Triglycerides in plasma originate either from fats in our food, or are made in the body from other energy sources, such as carbohydrates. Calories we consume but are not used immediately by our tissues are converted into triglycerides and stored in fat cells. When your body needs energy and there is no food as an energy source, triglycerides will be released from fat cells and used as energy - hormones control this process.

Omega 3

Omega-3 fatty acids are considered essential fatty acids: They are necessary for human health but the body can't make them -- you have to get them through food. Omega-3 fatty acids can be found in fish, such as salmon, tuna, and halibut, other seafood including algae and krill, some plants, and nut oils. They have also become popular because they may reduce the risk of heart disease. Some studies suggest that omega-3 fatty acids may help increase levels of calcium in the body and improve bone strength, although not all results were positive.

Functions of fats in the body?

1. The main function of fats in the body is to provide energy: By supplying energy, fats save proteins from being used for energy and allow them to perform their more important role of building and repairing tissues. Fats on oxidation provide almost twice as much energy as that given by carbohydrates. The fats provide on oxidation about 37 kJ of energy per gram as compared to 17kj of energy per gram of carbohydrates. Fats yield more energy than carbohydrates because fats contain less percentage of oxygen and higher percentage of carbon and hydrogen as compared with carbohydrates. Fats can also be stored in body for subsequent use. When we consume food which has more energy than is required by the body for performing various functions, the excess food is deposited under our skin in the form of subcutaneous fat.
2. In addition to supplying energy, fats also help in forming structural material of cells and tissues such as the cell membrane.
3. Fats also carry the fats soluble vitamins A, D, E and K into the body and help in the absorption of these vitamins in the intestines.
4. Some fats supply essential fatty acids.

Function of Fats in Body

- Triglycerides, cholesterol and other essential fatty acids—the scientific term for fats the body can't make on its own—store energy, insulate us and protect our vital organs. They act as messengers, helping proteins do their jobs. They also start chemical reactions that help control growth, immune function, reproduction and other aspects of basic metabolism.
- The cycle of making, breaking, storing and mobilizing fats is at the core of how humans and all animals regulate their energy. An imbalance in any step can result in disease, including heart disease and diabetes. For instance, having too many triglycerides in our bloodstream raises our risk of clogged arteries, which can lead to heart attack and stroke

- Fats help the body stockpile certain nutrients as well. The so-called "fat-soluble" vitamins—A, D, E and K—are stored in the liver and in fatty tissues.

Deficiency of fats

Deficiency of fats causes dry skin, hair loss, scaly skin, loss of menstruation, cold intolerance, poor resistance to infection, and bruising. Low fat in the diet can also affect brain function and lead to metabolic syndrome. A low-fat and low-cholesterol diet can create deficiencies associated with increased rates of depression and suicide.

Vitamins *and* Minerals

Q: **What is the significance of Vitamins? Describe the sources, uses and deficiency symptoms of fat soluble vitamins.** (CSS 2017)

Vitamins are organic substances (made by plants or animals), minerals are inorganic elements that come from the earth; soil and water and are absorbed by plants. Animals and humans absorb minerals from the plants they eat. Vitamins and minerals are nutrients that body needs to grow and develop normally.

Vitamins and minerals are considered essential nutrients—because acting in concert, they perform hundreds of roles in the body. They help shore up bones, heal wounds, and bolster your immune system. They also convert food into energy, and repair cellular damage.

Vitamins and minerals have a unique role to play in maintaining health. For example Vitamin D helps body absorb the amount of calcium (a mineral) it needs to form strong bones. A deficiency in vitamin D can result in a disease called rickets (softening of the bones caused by the body's inability to absorb the mineral calcium.) The body cannot produce calcium; therefore, it must be absorbed through our food. Other minerals like chromium, copper, iodine, iron, selenium, and zinc are called trace minerals because you only need very small amounts of them each day. The best way to get enough vitamins is to eat a balanced diet with a variety of foods.

The difference between Vitamins and Minerals

Although they are all considered micronutrients, vitamins and minerals differ in basic ways. Vitamins are organic and can be broken down by heat, air, or acid. Minerals are inorganic and hold on to their chemical structure.

So why does this matter? It means the minerals in soil and water easily find their way into your body through the plants, fish, animals, and fluids you consume. But it's tougher to shuttle vitamins from food and other sources into your body because cooking, storage, and simple exposure to air can inactivate these more fragile compounds.

Vitamins

Vitamins are nutrients you must get from food because your body can't make them from scratch. You need only small amounts (that's why they are often referred to as micronutrients) because the body uses them without breaking them down, as happens to carbohydrates and other macronutrients.

So far, 13 compounds have been classified as vitamins. Vitamins A, D, E, and K, the four fat-soluble vitamins, tend to accumulate in the body. Vitamin C and the eight B vitamins—biotin, folate, niacin, pantothenic acid, riboflavin, thiamin, vitamin B6, and vitamin B12—dissolve in water, so excess amounts are excreted.

The "letter" vitamins sometimes go by different names. These include:

- **Vitamin A** *retinol, retinaldehyde, retinoic acid*
- **Vitamin B1** *thiamin*
- **Vitamin B2** *riboflavin*

- **Vitamin B6** *pyridoxine, pyridoxal, pyridoxamine*
- **Vitamin B12** *cobalamin*
- **Vitamin C** *ascorbic acid*
- **Vitamin D** *calciferol*
- **Vitamin E** *tocopherol, tocotrienol*
- **Vitamin K** *phylloquinone*

Vitamins are divided into two groups: water-soluble (B-complex vitamins and C vitamins) and fat-soluble vitamins (A, D, E and K). Unlike water-soluble vitamins that need regular replacement in the body, fat-soluble vitamins are stored in the liver and fatty tissues, and are eliminated much more slowly than watersoluble vitamins

Fat-Soluble Vitamins

The fat-soluble vitamins, A, D, E, and K, are stored in the body for long periods of time and generally pose a greater risk for toxicity when consumed in excess than water-soluble vitamins. Eating a normal, well-balanced diet will not lead to toxicity in otherwise healthy individuals. However, taking vitamin supplements that contain megadoses of vitamins A, D, E and K may lead to toxicity. The body only needs small amounts of any vitamin.

Water-Soluble Vitamins

B-complex Vitamins

Eight of the water-soluble vitamins are known as the vitamin B-complex group: thiamin (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), vitamin B6 (pyridoxine), folate (folic acid), vitamin B12, biotin and pantothenic acid. The B vitamins are widely distributed in foods, and their influence is felt in many parts of the body. They function as coenzymes that help the body obtain energy from food. The B vitamins are also important for normal appetite, good vision, and healthy skin, nervous system, and red blood cell formation.

Difference between fat soluble and water soluble vitamins

Fat Soluble Vitamins	Water Soluble Vitamins
Fat soluble vitamins are those that are normally stored in the body.	Water soluble vitamins are vitamins that our bodies do not store
These vitamins are ingested, they dissolve in fat In a person with a healthy digestive system, the body uses what it needs at that time and stores the rest for future use	These vitamins dissolve in water when they are ingested, then go in to the blood stream. The body keeps what it needs at that time, and excess amounts are excreted in the urine.
Since people with cystic fibrosis often have pancreatic insufficiency and do not digest or store fats properly, the excess is not stored but excreted in the stool. Due to this, people with cystic fibrosis need a continuous supply of fat soluble vitamins just as they do with water soluble vitamins.	Since they can't be stored, everybody needs a continuous supply of water soluble vitamins in order to stay healthy.
Examples are Vitamins A, D, E and K	Examples are Vitamin C and all of the B vitamins

Sources of Vitamins (CSS 1990)

Vitamin and Mineral Table

Vitamin/Mineral	Found in	What it does
Vitamin A (CSS 2012) *(Retinol or Beta-carotene)*	Liver, egg yolk, dairy products, margarine. Beta carotene (pro-vitamin A) is found in dark green and deep yellow fruits and vegetables	Keeps eyes healthy; develops bones; protects linings of respiratory, digestive and urinary tracts; maintains healthy skin and hair. Beta carotene fights free radicals (chemicals that damage cells).
Vitamin B_1 *(Thiamine)*	Whole grains, cereals and enriched grain products; also legumes (dried beans, peas, and nuts), organ meats, lean pork and eggs	Promotes healthy functioning of the nerves, muscles and heart. Metabolizes carbohydrates.
Vitamin B_2 *(Riboflavin)*	Organ meats, enriched breads and cereals, legumes, almonds, cheese and eggs; also meat, fish and dark green vegetables	Metabolizes carbohydrates, fats and proteins, produces hormones; promotes eye and skin health.
Vitamin B_3 *(Niacin)*	Meat, organ meats, whole grains and cereals, and legumes; also eggs, milk, green leafy vegetables and fish	Metabolizes carbohydrates and fats; helps functioning of digestive system; maintains health skin.
Vitamin B_5 *(Pantothenic Acid)*	Organ meats, yeast, raw vegetables, eggs and dairy products	Produces hormones and maintains body's immune system.
Vitamin B_6 *(Pyridoxine)*	Whole-grain products, poultry, fish, and nuts; also meat, most fruits and vegetables, eggs and dairy products	Metabolizes protein; helps produce hemoglobin; promotes functioning of digestive and nervous systems, and healthy skin
Vitamin B_{12} *(Cyanocobalamin)*	Primarily organ meats; also fish, lean meats, poultry, cheese, and eggs.	Builds genetic material of cells and produces blood cells.
Vitamin C (CSS 2012) *(Ascorbic Acid)*	Almost exclusively fruits and vegetables (especially citrus fruits, tomatoes, peppers, strawberries, and cantaloupe) although breast milk and organ meats contain small amounts.	An antioxidant, fights and resists infection; heals wounds; promotes growth and maintenance of bones, teeth, gums, ligaments and blood vessels.
Vitamin D *(Cholecalciferol)*	For most people, sun exposure is the primary source of vitamin D. Food sources include Vitamin D-fortified milk, eggs, fish-liver oils and fatty fish such as herring, mackerel and salmon.	Builds strong bones and teeth and maintains the nervous system

Vitamin E *(Tocopherol)*	Vegetable oils, nuts, wheat germ and whole-wheat products, egg yolks and green leafy vegetables.	Protects the lungs, nervous system, skeletal muscle and the eye's retina from damage by free radicals; may reduce risk of heart disease by protecting against atherosclerosis.
Vitamin H (Biotin)	Oats, organ meats, yeast and eggs (cooked); also whole-wheat products, dairy products, fish and tomatoes	Metabolizes proteins and carbohydrates; breaks down fatty acids.
Vitamin K	Dark green leafy vegetables, eggs, cheese, pork and liver	Promotes normal blood clotting
Vitamin M (Folic Acid)	Vegetables (especially dark-green ones), organ meats, whole-wheat products, legumes and mushrooms.	Synthesis of protein and genetic materials; may help prevent some cancers, heart disease and stroke; when taken during pregnancy, protects against some birth defects

Toxicity of Vitamins

Vitamins are grouped into two broad categories: water soluble vitamins (thiamine, niacin, riboflavin, pantothenate, vitamin B12, folic acid, ascorbic acid) and fat soluble vitamins (vitamin E (tocopherols), vitamin D, vitamin A, vitamin K). It is a general rule that there is very little danger of consuming toxic levels of water soluble vitamins; because they are soluble in water, their elimination from the body is very efficient. So when the body recognizes that the intake of water soluble vitamins exceeds daily needs, the elimination process becomes more efficient and the excess is voided from the body in the urine.

With fat soluble vitamins there is more danger. Fat soluble vitamins are not as quickly eliminated from the body, but rather are stored in fat tissues and in various organs throughout the body. The regulation of the body levels of these vitamins is therefore not as precise as for the water soluble vitamins and long term consumption at levels above those required can mean the buildup of toxic levels of fat soluble vitamins in the body. Toxic symptoms have been recorded but for some fat soluble vitamins such as vitamin E and vitamin K it has been difficult to establish the effects of chronic (long term) consumption levels.

Dietary mineral

Dietary minerals are the chemical elements required by living organisms Appropriate intake levels of each dietary mineral must be sustained to maintain physical health. Mineral nutrients are classified as major elements (calcium, chlorine, magnesium, phosphorus, potassium, sodium, and sulfur) and trace elements (chromium, copper, fluoride, iodine, iron, selenium, and zinc).

Minerals	Major Functions	Deficiency Symptoms
Calcium (CSS 2012) *Calcium is a major mineral. The human body contains more than any other mineral. Ninety-nine % of your body's calcium is in your bones*	Builds and maintains strong bones and teeth. Helps to regulate heart rhythm and muscle contractions. Lowers blood pressure. Aids in regulation of water balance in cells. Helps regulate the passage of nutrients in & out of the cell walls. Important to normal kidney function	Rickets (softening of bones in infants and children. Poor growth in children. Tooth decay, possibly high blood pressure, arm and leg muscles spasms, back and leg cramps
Chromium	Important in the metabolism of carbohydrates and fats. Works with insulin to help the body use glucose or blood sugar. Helps control the appetite	Low blood sugar levels. Impaired glucose tolerance. Impaired growth
Copper	Aids in the formation of red blood cells. Helps production of energy in the cells. Maintains blood vessels, nerves and the immune system. Helps proper bone formation & maintenance. Necessary for the absorption & utilization of iron	Anemia, Loss of color in the skin and hair, Damage to the brain and spinal cord, General weakness, Skin sores, Fatigue, Bone fragility
Fluoride	Helps harden tooth enamel, and protects against tooth decay. May help prevent osteoporosis, or brittle bone disease	Increases dental caries (cavities), Weak tooth enamel.
Iodine (CSS 2012)	Aids in the development and functioning of the thyroid gland. Needed for normal growth and development, regulates the body's production of energy	Goiter, enlarged thyroid gland. Loss of physical and mental vigor. Dry skin and hair and weight gain
Iron (CSS 2012) *They play a major role in health, since even minute portions of them can powerfully affect health*	Increases resistance to stress and disease. It is part of several enzymes and proteins. Needed for the red blood cell formation and oxygen delivery to tissues and the brain. Prevents fatigue and promotes good skin tone	Anemia, fatigue from anemia, decrease in immune function, paleness of skin, constipation, brittle fingernails.
Magnesium	Aids in bone growth and the function of nerves, bones and muscles. Required for regulation of normal heart rhythm. Aids in regulation of blood pressure and water balance in cells	Nausea, muscle weakness, irritability, abnormalities in heart rhythm, growth failure, leg cramps, kidney stones
Phosphorus	Required for formation of healthy bones and teeth, second to only calcium. Necessary for energy metabolism	Bone loss characterized by weakness, loss of appetite, and pain. Continuous thirst. Dry skin and general weakness
Potassium	An electrolyte that helps maintain acid-base balance. Helps muscles contract and	Weakness, anorexia and nausea. Fatigue, muscle

	transmits nerve impulses. Helps with proper function of heart and kidneys. Helps maintain normal blood pressure. Promotes healthy skin.	damage, irregular heartbe
Sodium	Helps regulate blood pressure and water balance in cells. Helps maintain acid-base balance. Aids in muscle contraction and nerve impulse transmission	Weakness, dizzines headache and muscle cramp
Zinc	Necessary for cell division, growth and proper functioning of the immune system. Plays a role in taste and smell acuity. Important in carbohydrate metabolism and DNA replication. Plays a role in male hormone production. Vital for the development of the reproductive organs. Serves as an antioxidant nutrient. Aids in the digestion and metabolism of phosphorus. Necessary for wound healing. Helps maintain healthy skin and hair	Loss of appetite (related t loss of sense of taste). Sk changes. Susceptibility t infections. Slowed woun healing, fatigue. White sp on finger nails

Disease Caused *by* Deficiency (CSS 1987)

Diseases that are caused by the lack of some particular nutrient in a person's diet a called deficiency diseases.

1. Night-blindness:

A child having this disease is unable to see properly in the dark. His eyes become d and listless and the skin becomes dry. If not treated in time, the child may become blind.

Cause:

This disease is caused due to the deficiency of vitamin A in the diet.

Treatment: A child suffering from night-blindness should take a diet rich in vitamin A Carrots, fish, fruits, milk, butter, etc., are all good sources of vitamin A.

2. Beri-beri:

This is basically a disorder of the nerves. It affects the health of eyes % and skin, grow of the body, formation of muscles and blood. There may also to be stomach and intestin disturbances.

Cause:

This disease is caused due to the deficiency of vitamin-B.

Treatment:

The affected child must eat the foods rich in vitamin B like milk, fish, meat, cereals eg etc., and also seek medical advice from a doctor.

3. Scurvy:

People suffering from scurvy have swollen and bleeding gums. They lose weight an become weak. Their teeth start shaking and become loose.

Cause:

This disease is caused due to the deficiency of vitamin-C.

Treatment:

Oranges, citrus fruits, cabbage, amla, etc., should be included in the diet of the patient.

4. Rickets:

In this disease, the bones of the legs become thin, deformed and curved (bow-legged). The bones of the child become weak and soft.

Cause:

This disease is caused due to the deficiency of vitamin D.

Treatment:

The affected child must eat the foods rich in vitamin D like milk, fish, meat, butter, egg, etc., and take the advice of a doctor.

5. Anaemia:

In this disease, the level of the haemoglobin becomes low gets tired very easily and feels weak. The skin becomes pale. The lips and nails become dull and colourless.

Cause:

This disease is caused due to the deficiency of iron.

Treatment:

The person should have plenty of green, leafy vegetables like spinach and cabbage. Meat, apples, beans, dry fruits, etc., should be included in the diet.

A doctor must also be consulted immediately.

6. Goitre:

In this disease, there is swelling around the neck region of a person.

Cause:

This disease is caused due to the deficiency of iodine.

Treatment:

The affected person needs to add iodised salt to his or her food.

7 Malnutrition

A child in this condition becomes weak and thin. He shows poor growth compared to other children. He gets tired easily. There may be swelling on the feet and hands. The hair becomes very thin and skin of the child gets dark and starts peeling. Such a child is said to be suffering from malnutrition.

Cause:

Deficiency of proteins and carbohydrates causes this disease.

Treatment:

Patients of this deficiency should eat food rich in proteins and carbohydrates. Milk, cereals, starch and sugars, meat and eggs should be a part of their diet.

|| Water ||

If the importance of a nutrient is judged by how long we can do without it, water ranks is the most important. A person can survive only eight to ten days without water, whereas it takes weeks or even months to die from a lack of food. Water circulates through our blood and lymphatic system, transporting oxygen and nutrients to cells and removing wastes through urine and sweat. Water also maintains the natural balance between dissolved salts and water inside and outside of cells. Our joints and soft tissues depend on the cushioning that water provides for them. While water has no caloric value and therefore is not an energy source, without it in our diets we could not digest or absorb the foods we eat or eliminate the body's digestive waste.

The human body is 65 percent water, and it takes an average of eight to ten cups to replenish the water our bodies lose each day. How much water a person needs depends largely on the volume of urine and sweat lost daily, and water needs are increased if a person suffers from diarrhea or vomiting or undergoes heavy physical exercise.

Water is replenished by drinking liquids, preferably those without caffeine or alcohol, both of which increase the output of urine and thus dehydrate the body. Many foods are also a good source of water-fruits and vegetables, for instance, are 80 to 95 percent water; meats are made up of 50 percent water; and grains, such as oats and rice, can have as much as 35 percent water.

Functions of Water

Water is involved in many of our body's vital functions

Cell life

Water is a carrier, distributing essential nutrients to cells, such as minerals, vitamins and glucose.

Chemical and metabolic reactions

Water removes waste products including toxins that the organs' cells reject, and removes them through urines and faeces.

Transport of nutrients

Water participates in the biochemical break-down of what we eat.

Body temperature regulation

Water has a large heat capacity which helps limit changes in body temperature in a warm or a cold environment. Water allows the body to release heat when ambient temperature is higher than body temperature (1). The body begins to sweat, and the evaporation of water from the skin surface very efficiently cools the body.

Elimination of water

Water is an effective lubricant around joints. It also acts as a shock absorber for eyes, brain, spinal cord and even for the foetus through amniotic fluid.

Water is at the center of life. This is why nobody can live more than 3 to 5 days without any water intake.

What is Dehydration?

Dehydration is a condition that occurs when someone loses more fluids than he or she akes in. Dehydration isn't as serious a problem for teens as it can be for babies or young children. But if you ignore your thirst, dehydration can slow you down.

Our bodies are about two thirds water. When someone gets dehydrated, it means the amount of water in his or her body has dropped below the level needed for normal body function. Small decreases don't cause problems, and in most cases, they go completely unnoticed. But not drinking enough to keep up with the loss of fluid can sometimes make a person feel quite sick.

Effects of Dehydration

Mild Dehydration

- Urine will become concentrated and turn an amber colour due to kidneys conserving water.
- Constipation and/or bloating may be noticed.
- Dry skin, mucous membranes, and lips.

Moderate Dehydration

- Fatigue.
- Dizziness / vertigo / lightheaded.
- Problems concentrating.
- Major reduction in urine production.
- Headache.
- Cold hands and fee

Severe Dehydration

- Weak irregular heart beat (often racing) and low blood pressure
- Rapid breathing
- Failure of body's heat regulation systems (sweating, for example)
- Confusion
- Vomiting and/or diarrhea
- Seizures
- Coma and death

Dietary Fiber

What is Fiber?

Fiber is indigestible carbohydrate found in plant foods, such as fruits, vegetables, and grain products. Our body cannot digest fiber (because our enzymes cannot break it down) and therefore passes through our body largely intact

Fiber can be divided into two categories: *insoluble* and *soluble*. Each form functions differently and delivers unique health benefits.

1. **Soluble fiber:** Found in oats, peas, beans, barley, rye, and certain fruits such as apples, pears, oranges, peaches, grapes, and prunes. Soluble fiber is not only useful for digestion but has also been scientifically proven to reduce blood-cholesterol levels, which may help reduce the risk of heart disease.
2. **Insoluble fiber:** Found in fruits, vegctables, dried beans, wheat bran, seeds, popcorn, brown rice, and whole-grain products such as breads, cereals and pasta. Insoluble fiber is particularly important for cleansing the digestive tract. Insoluble fibers hold on to water, helping move waste through the body and decreasing the time that potentially harmful

substances stay in the colon.

Sources of Soluble Fiber

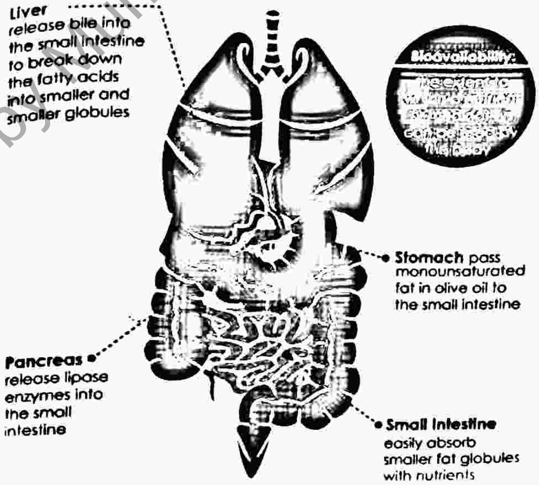
Legumes such as pinto beans, kidney beans, black beans, peas, lentils. Various bran, rice, oat, barley, corn, wheat. Fruits and vegetables including apples, oranges, pears, carrots, peaches, grapes, potatoes, and squash. Corn and popcorn. Seeds and nuts. Whole-grain breads, cereals and pasta. Psyllium seed

Sources of Insoluble Fiber

Wheat bran and whole grain products such as bread, crackers, some breakfast cereals, bran muffins. Whole-wheat flour, brown rice, kidney beans. Skins of many fruits such as strawberries, boysenberries, pears, apples, prunes. Vegetables including green beans, broccoli, peppers, spinach, carrots, tomatoes and artichokes. *These may also contain some soluble fiber.* Almonds, chunky peanut butter.

Nutrient Bioavailability

When we consume a food or drink, the nutrients contained are released from the matrix, absorbed into the bloodstream and transported to their respective target tissues. However, not all nutrients can be utilized to the same extent. In other words, they differ in their bioavailability. Understanding nutrient bioavailability helps optimize diets and set appropriate nutrient recommendations.


Liver
release bile into the small intestine to break down the fatty acids into smaller and smaller globules
Bioavailability:
Stomach pass monounsaturated fat in olive oil to the small intestine
Pancreas
release lipase enzymes into the small intestine
Small Intestine
easily absorb smaller fat globules with nutrients

Defining nutrient bioavailability

Several definitions exist for nutrient bioavailability, but broadly it refers to the proportion of a nutrient that is absorbed from the diet and used for normal body functions. The following components describe the different steps of the metabolic pathway where changes in nutrient bioavailability may occur:

- release of the nutrient from the physicochemical dietary matrix
- effects of digestive enzymes in the intestine
- binding and uptake by the intestinal mucosa
- transfer across the gut wall (passing through the cells, in-between them or both) to the blood or lymphatic circulation
- systemic distribution
- systemic deposition (stores)

- metabolic and functional use
- excretion (via urine or faeces)

As is evident from this list, the bioavailability of a nutrient is governed by external and internal factors. External factors include the food matrix and the chemical form of the nutrient in question, whereas gender, age, nutrient status and life stage (e.g. pregnancy) are among the internal factors. Because aspects such as nutrient status also determine whether and how much of a nutrient is actually used, stored or excreted, some definitions of bioavailability restrict themselves to the fraction of a nutrient that is absorbed.

The bioavailability of macronutrients – carbohydrates, proteins, fats – is usually very high at more than 90% of the amount ingested. On the other hand, micronutrients, i.e. vitamins and minerals, and bioactive phytochemicals (e.g. flavonoids, carotenoids) can vary widely in the extent they are absorbed and utilized. Therefore, the following sections will use micronutrients and phytochemicals as examples to illustrate the different stages at which nutrient bioavailability can be influenced.

Effects of food matrix and chemical form of nutrients

The first step in making a nutrient bioavailable is to liberate it from the food matrix and turn it into a chemical form that can bind to and enter the gut cells or pass between them. Collectively this is referred to as bio accessibility. Nutrients are rendered bio accessible by the processes of chewing (mastication) and initial enzymatic digestion of the food in the mouth, mixing with acid and further enzymes in the gastric juice upon swallowing, and finally release into the small intestine, the major site of nutrient absorption.

Minerals and other nutrients exist in different chemical forms in the food and this can influence their bioavailability. A classic example is iron. In general we talk about two types of dietary iron; haem and non-haem iron. The former is only found in meat, fish and poultry, whereas the latter occurs in foods of plant and animal origin. Haem iron mainly stems from the haemoglobin and myoglobin molecules responsible for oxygen transport and storage in the blood and muscles, respectively. Once released from the food matrix, the haem molecule acts like a protective ring around the central iron atom. Thus, it shields the iron from interaction with other food components, keeps it soluble in the intestine, and is absorbed intact through a specific transport system on the surface of the gut cells. In contrast, non-haem iron is poorly soluble under intestinal conditions and easily affected by other components of the diet. Therefore only a small fraction is taken up by the cells.

Sometimes vitamins and minerals are added to foods to increase their nutritional value - a process called fortification. In the case of the B vitamin folic acid, which is often added to breakfast cereals, flour and certain spreads, this added folic acid usually is more bioavailable than that naturally present in the food, commonly referred to as dietary folate. Studies reported 20-70% lower bioavailability of dietary folate (from fruits, vegetables or liver) vs synthetic folic acid. This does not mean though that one should only consume foods fortified with folic acid, but rather that natural dietary sources such as green leafy vegetables can be complemented with foods fortified with this vitamin to ensure that individual requirements are met.

Enhancers of nutrient bioavailability

Nutrients can interact with one another or with other dietary components at the site of absorption, resulting in either a change in bioavailability or – if enhancers and inhibitors cancel each other out – a nil effect. Enhancers can act in different ways such as keeping a nutrient soluble or protecting it from interaction with inhibitors. For example, since carotenoids are fat-soluble, adding small quantities of fat or oil to the meal (3-5 g per meal) improves their bioavailability. Similarly, meat, fish and poultry, while containing highly bioavailable iron themselves, are also known to enhance the absorption of iron from all foods. Although this 'meat factor' has yet to be identified, an influence of the muscle protein has been suggested.

Vitamin C is also a strong 'helper', being able to increase iron absorption by two or three times. This means, for example, having a glass of orange juice with a bowl of breakfast cereal helps the body use more of the iron in the cereal.

Impact of inhibitors on nutrient bioavailability

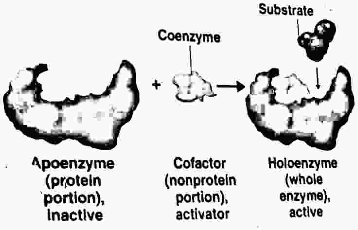
Inhibitors may reduce nutrient bioavailability by:

1. binding the nutrient in question in a form that is not recognized by the uptake systems on the surface of intestinal cells,
2. rendering the nutrient insoluble and thus unavailable for absorption, or
3. competing for the same uptake system.

Phytic acid is highly abundant in certain plant foods (e.g. pulses, whole-grain cereals, seeds, nuts) and strongly binds minerals such as calcium, iron and zinc in soluble or insoluble complexes that are unavailable for absorption. An example of competition for the same uptake system is the interaction between calcium and non-haem iron. Both minerals bind to a transporter on the surface of intestinal absorptive cells, but whereas non-haem iron enters the cells this way, calcium basically stays in the doorway and hinders further entry of the iron. This effect is mainly relevant when calcium and or iron supplements are used outside the meal setting. Therefore, the best advice is to use those supplements at different times of day so as to avoid this interference.

Enzyme

Enzyme, any one of many specialized organic substances, composed of polymers of amino acids that act as catalysts to regulate the speed of the many chemical reactions involved in the metabolism of living organisms. The name enzyme was suggested in 1867 by the German physiologist Wilhelm Kühne (1837-1900); it is derived from the Greek phrase en zyme, meaning "in leaven"


Substrate
Coenzyme
+
Apoenzyme (protein portion), inactive
Cofactor (nonprotein portion), activator
Holoenzyme (whole enzyme), active

Enzymes are classified into several broad categories, such as hydrolytic, oxidizing, and reducing, depending on the type of reaction they control. Hydrolytic enzymes accelerate reactions in which a substance is broken down into simpler compounds through reaction with water molecules. Oxidizing enzymes, known as oxidases, accelerate oxidation reactions; reducing enzymes speed up reduction reactions, in which oxygen is removed. Many other enzymes catalyze other types of reactions.

Individual enzymes are named by adding *ase* to the name of the substrate with which they react. The enzyme that controls urea decomposition is called urease; those that control protein hydrolyses are known as proteinases. Some enzymes, such as the proteinases trypsin and pepsin, retain the names used before this nomenclature was adopted.

Structure of Enzyme

Apoenzyme:

The polypeptide or protein part of the enzyme is called the *apoenzyme* and may be inactive in its original synthesized structure.

The inactive form of the *apoenzyme* is known as a *proenzyme or zymogen*. The proenzyme may contain several extra amino acids in the protein which are removed, and allows the final specific tertiary structure to be formed before it is activated as an apoenzyme.

Cofactors

A cofactor is a non-protein substance which may be organic, and called a **coenzyme**. The **coenzyme** is often derived from a vitamin with specific examples discussed later.

Another type of cofactor is an inorganic metal ion called a **metal ion activator**. The inorganic metal ions may be bonded through coordinate covalent bonds. The major reason for the nutritional requirement for minerals is to supply such metal ions as Zn^{+2}, Mg^{+2}, Mn^{+2}, Fe^{+2}, Cu^{+2}, K^{+}, and Na^{++} for use in enzymes as cofactors.

Final Enzyme

The type of association between the cofactor and the apoenzymes varies. In some cases, the bonds are rather loose and both come together only during the course of a reaction. In other cases, they are firmly bound together by covalent bonds. The activating role of a cofactor is to either: activate the protein by changing its geometric shape, or by actually participating in the overall reaction.

The overall enzyme contains a specific geometric shape called the *active site* where the reaction takes place. The molecule acted upon is called the *substrate*.

Enzyme Characteristics:

A living system controls its activity through enzymes.

An enzyme is a protein molecule that is a biological catalyst with three characteristics.

- **First**, the basic function of an enzyme is to increase the rate of a reaction. Most cellular reactions occur about a million times faster than they would in the absence of an enzyme
- **Second**, most enzymes act specifically with only one reactant (called a *substrate*) to produce products
- *The* **third** and most remarkable characteristic is that enzymes are regulated from a state of low activity to high activity and vice versa. Gradually, you will appreciate that the individuality of a living cell is due in large part to the unique set of some 3,000 enzymes that it is genetically programmed to produce. If even one enzyme is missing or defective, the results can be disastrous.

Industrial uses of enzymes

Some enzymes have a long tradition of industrial use. For example, in leather tanning, hides have for centuries been softened and hair removed using proteases naturally present in faeces. In brewing, enzymes present in barley grains at germination are used to convert the starch stored in the grain to sugars and the proteins to amino acids. These sugars and amino acids are then used by yeast for growth and alcohol production. In cheese manufacture, the proteins in

milk are coagulated by using the stomach enzyme rennin, obtained from veal calves. Todays *there are many new developments in the use of enzymes as industrial catalysts.*

Advantages of using Enzymes rather than Inorganic Catalysts

- They are highly specific.
- They are efficient – a tiny quantity of enzyme catalyses the production of a huge quantity of products.
- They work at normal temperatures and pressures, so need much less energy than most chemical catalysts.

Sources of Industrial Enzymes

Useful enzymes are obtained from both plant and animal sources, but most enzymes are obtained from microorganisms, mainly bacteria and fungi. The advantages of microoganisms are:

- They are grown economically in bulk fermenters.
- They have high growth rates and contain a larger proportion of enzymes in relation to their body mass than plants or animals.
- Their growth is not limited by season or climate.
- They occur naturally in a wide range of habitats, and so some contain enzymes that will function under extremes of temperature or pH.
- They can be genetically manipulated, for example a human gene for insulin production has been introduced into a bacterium called E. coli.

Food Additives

Key facts

- Food additives are substances added to food to maintain or improve its safety, freshness, taste, texture, or appearance.
- Food additives need to be checked for potential harmful effects on human health before they can be used.

What are food additives?

Substances that are added to food to maintain or improve the safety, freshness, taste, texture, or appearance of food are known as food additives. Some food additives have been in use for centuries for preservation – such as salt (in meats such as bacon or dried fish), sugar (in marmalade), or sulfur dioxide (in wine).

Many different food additives have been developed over time to meet the needs of food production, as making food on a large scale is very different from making them on a small scale at home. Additives are needed to ensure processed food remains safe and in good condition throughout its journey from factories or industrial kitchens, during transportation to warehouses and shops, and finally to consumers.

The use of food additives is only justified when their use has a technological need, does not mislead consumers, and serves a well-defined technological function, such as to preserve the nutritional quality of the food or enhance the stability of the food.

Food additives can be derived from plants, animals, or minerals, or they can be synthetic. They are added intentionally to food to perform certain technological purposes which consumers often take for granted. There are several thousand food additives used, all of which are designed to do a specific job in making food safer or more appealing.

Types of Food Additives

Below is a rough categorization of additive types. Some additives belong to more than one category. For example, sugar is both a preservative and a sweetener.

1) **Acids** - added to make flavors "sharper", and also act as preservatives and antioxidants. Common food acids include ***vinegar***, *citric acid* and *ascorbic acid* (vitamin C).
2) **Anticaking agents** - keep powders such as milk powder from caking or sticking. A very popular one is ***sodium bicarbonate*** (baking soda).
3) **Bulking agents** - additives that increase the bulk of a food without affecting its nutritional value. As examples, you'll often find ***modified food starch*** or ***modified corn starch*** and on labels.
4) **Food coloring** - added to food to replace colors lost during preparation, or to make food look more attractive. May be natural or artificial, the latter are much cheaper to use. Unfortunately, artificial food colorings, such as ***Yellow 5*** have been linked to behavioral problems in children. Some food colorings approved for use in the US have been banned in Europe and Japan.
5) **Emulsifiers** - allow water and oils to remain mixed together in an emulsion, as in mayonnaise, ice cream, and homogenized milk. On labels look for ***sodium phosphates***, ***lecithin***, and ***diglycerides***, to name a few.
6) **Stabilizers / gelling agents** - give foods a firmer texture, and help to stabilize emulsions. ***Pectin*** and ***agar*** are examples used in making jellies and jams.
7) **Thickeners** - similar to emulsifiers/stabilizers - increase a mixture's viscosity without modifying its other properties. May be derived from starches or from proteins. ***Xantham gum*** is commonly used as a thickener.
8) **Flavors** - natural and artificial - while natural sounds healthier, this may not always be the case (see poison mushrooms). Flavors are added to foods to enhance their aroma and entice you to buy them and then eat them.
9) **Humectants** - prevent foods from drying up. **Glycerine** is an example.
10) **Preservatives** - prevent food from spoiling due to to mold, bacteria and other microorganisms. Three natural preservatives are ***salt***, ***sugar***, and ***vinegar***. But there are many more artificial preservatives in use today, such as ***nitrates*** and ***nitrites*** found in meats. Home baked bread goes stale after 36 hours, and starts to develop mold within 4 days, but a loaf from the supermarket will keep for more than a week due to ***propionates*** which prevent mold.
11) **Sweeteners** - Sugar and high fructose corn syrup (HFCS, yes some call it the mother of all evil) are considered natural, whereas ***splenda*** and ***sucralose*** are artificial and contain close to zero calories, making them a possible solution for weight watchers and diabetics.

Antioxidants

Antioxidants protect the body from damage caused by harmful molecules called free radicals. Many experts believe this damage is a factor in the development of blood vessel disease (atherosclerosis), cancer, and other conditions.

Antioxidants, type of molecule that neutralize harmful compounds called *free radicals* that damage living cells, spoil food, and degrade materials such as rubber, gasoline, and lubricating oils. Antioxidants can take the form of enzymes in the body, vitamin supplements, or industrial additives. They are routinely added to metals, oils, foodstuffs, and other materials to prevent free radical damage

Antioxidants work to control the levels of free radicals before they do oxidative damage to the body. For example, certain enzymes in the body, such as superoxide dismutase (SOD), work with other chemicals to transform free radicals into harmless molecules. Dietary antioxidants supplement the action of enzymes that occur naturally in the body, and some studies show that a diet high in foods that are rich in antioxidants may decrease the risk of cancer and heart disease.

Vitamins C and E are well known antioxidants that may prevent cataracts and cancers of the stomach, throat, mouth, and pancreas. They may also protect from heart disease and strengthen the immune system. Good sources of vitamin E include wheat germ oil and sunflower seeds .Caffeine in various foods has been variously implicated to have a healthful antioxidant activity against some free radicals inside the body. Caffeine, active ingredient in coffee may increase the effectiveness of gastrointestinal uptake of some pain killers, especially in patients with migraine and headache medications

Examples of Antioxidants

Vitamin E, C and the carotenoids such as beta-carotene, lutein and lycopene are examples of the primary antioxidants in your diet. Other examples of antioxidants include selenium and vitamin A. Foods high in vitamin E include nuts, seeds, vegetables, fish oils and whole grains.

You can get vitamin C from a wide variety of fruits and vegetables. Foods rich in carotenoids include egg yolk, spinach, carrots, Brussels sprouts, peaches, grains, tomatoes, broccoli and sweet potatoes.

Free Radicals

These free radicals are atoms or groups of atoms that contain an odd number of electrons. They can be formed when certain molecules interact with oxygen. Once formed, free radicals can start a chain of damaging chemical reactions. The biggest danger to the human body is their potential to react with cellular components like DNA or the cell membrane, causing cells to function poorly or die.

Free radicals are not only generated by the body, they are present in foods you eat as well as in the air you breathe. Some even come through exposure to sunlight that can harm the eyes and the skin. Free radicals can trap a low-density lipoprotein (LDL) in an artery wall and begin the formation of plaque; they can damage DNA; or they can change the course of what enters and leaves a cell. Any of these actions can be the start of a disease process.

How the Body Defends Against Oxidative Stress

. Oxidative stress occurs when the production of free radicals goes beyond the protective defenses in the body. Oxidative stress and free radical damage to cells may initiate the early stages of cancer and heart disease. Free radicals are also suspect in the development of Alzheimer's disease, arthritis, cataracts, diabetes, kidney disease, and age-related blindness.

The human body is not without its own defenses against this damage. It creates many different types of molecules -- antioxidants -- to combat these free radicals and protect the cells from attack by oxygen. Antioxidants can safely interact with free radicals and stop the chain of damaging reactions before damage is done to cells. There are several enzyme systems in the body that scavenge free radicals, but we can also gain these helpful molecules from foods that we eat. Some vitamins are antioxidants, such as vitamins C and E. Some minerals are antioxidants, such as selenium and manganese, and there are plant compounds that act as antioxidants such as beta carotene and lycopene, terms you may have heard before or seen in ads for vitamin supplements.

Why are antioxidants in food important?

The body produces a range of its own protective antioxidants. Some foods are also rich in antioxidants and these may boost the body's own supply. There is some evidence that antioxidants in plant foods may become especially important as we age and produce more free radicals.

Plants produce hundreds of antioxidants for their own protection. Some that may also be useful to us are present in vegetables, fruits, herbs and spices, nuts and wholegrains. Tea, coffee, extra virgin olive oil, red wine and dark bitter chocolate are also rich in antioxidants.

Antioxidants produce the bright colours in fruits and vegetables and the flavour of extra virgin olive oil, tea or coffee. Bitter compounds in foods such as rocket are also potent antioxidants.

Claims that a particular food is the 'richest source of antioxidants' can be confusing as the claim may depend on the type of measurement used or refer to a particular antioxidant, such as lycopene in tomatoes, and does not necessarily consider how well particular antioxidants can be absorbed. The variety and combination of antioxidants in their natural food sources may also be important as isolated antioxidants may not function in the same beneficial way.

Food Preservation

(CSS 1987, 1995, 2001, 2008)

Q: Discuss importance of preservatives and antioxidants in food. (CSS-2016)

Food preservation is the process of treating and handling food to stop or greatly slow down spoilage (*loss of quality, edibility or nutritive value*) caused or accelerated by micro-organisms.

Some methods, however, use benign bacteria, yeasts or fungi to add specific qualities and to preserve food (*e.g., cheese, wine*). Maintaining or creating nutritional value, texture and flavour is important in preserving its value as food.

Preservation usually involves preventing the growth of bacteria, fungi, and other micro-organisms, as well as retarding the oxidation of fats which cause rancidity. It also includes processes to inhibit natural ageing and discoloration that can occur during food preparation such as the enzymatic browning reaction in apples which causes browning when apples are cut. Some preservation methods require the food to be sealed after treatment to prevent recontamination with microbes; others, such as drying, allow food to be stored without any special containment for long periods.

Methods of Food Preservation

Drying Food Preservation

One of the oldest methods of food preservation is by drying, which reduces water activity sufficiently to prevent or delay bacterial growth Drying also reduces weight, making food more portable. Drying is also the normal means of preservation for cereal grains such as wheat, maize, oats, barley, rice, millet and rye.

Food Preservation Freezing

Freezing is also one of the most commonly used processes commercially and domestically for preserving a very wide range of food including prepared food stuffs which would not have required freezing in their unprepared state.

Vacuum Packing Food Preservation

Vacuum-packing stores food in a vacuum environment, usually in an air-tight bag or bottle. Vacuum-packing is commonly used for storing nuts to reduce loss of flavor from oxidation.

Food Preservation Sugar

Sugar is used to preserve fruits, either in syrup with fruit such as apples, pears, peaches, apricots, plums or in crystallized form where the preserved material is cooked in sugar to the point of crystallisation and the resultant product is then stored dry

Canning and Bottling Food Preservation

Canning involves cooking food, sealing it in sterile cans or jars, and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization, inventor Nicolas Appert Food preserved by canning or bottling is at immediate risk of spoilage once the can or bottle has been opened.

Lack of quality control in the canning process may allow ingress of water or micro-organisms

Pulsed Electric Field Processing

Pulsed electric field (PEF) processing is a method for processing cells by means of brief pulses of a strong electric field. PEF holds potential as a type of low temperature alternative pasteurization process for sterilizing food products. PEF for food processing is a developing technology still being researched. There have been limited industrial applications of PEF processing for the pasteurization of fruit juices.

High Pressure Food Preservation

High pressure food preservation refers to high pressure used for food preservation. "Pressed inside a vessel exerting 70,000 pounds per square inch or more, food can be processed so that it retains its fresh appearance, flavour, texture and nutrients while disabling harmful microorganisms and slowing spoilage."

What is Malnutrition?

Malnutrition is a broad term which refers to both undernutrition (*subnutrition*) and overnutrition. Individuals are malnourished, or suffer from undernutrition if their diet does not provide them with adequate calories and protein for maintenance and growth, or they cannot fully utilize the food they eat due to illness. People are also malnourished, or suffer from overnutrition if they consume too many calories.

Malnutrition can also be defined as the insufficient, excessive or imbalanced consumption of nutrients. Several different nutrition disorders may develop, depending on which nutrients are lacking or consumed in excess.

- **Malnutrition** is *"Faulty nutrition resulting from malabsorption, poor diet, or overeating."*
- **Undernutrition** is *"A form of malnutrition resulting from a reduced supply of food or from inability to digest, assimilate, and use the necessary nutrients."*

In more wealthy industrialized nations malnutrition is usually caused by:

- Poor diet
- Mental health
- Mobility
- Digestive disorders and stomach conditions

In poorer, developing nations malnutrition is commonly caused by:

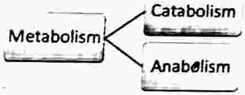
- Food shortages
- Food prices and food distribution
- Lack of breastfeeding

Signs and Symptoms of Malnutrition

- Loss of fat (*adipose tissue*)
- Breathing difficulties, a higher risk of respiratory failure
- Depression
- Higher risk of complications after surgery
- Higher risk of hypothermia - abnormally low body temperature
- The total number of some types of white blood cells falls; consequently, the immune system is weakened, increasing the risk of infections.
- Higher susceptibility to feeling cold
- Longer healing times for wounds
- Longer recover times from infections
- Longer recovery from illnesses
- Problems with fertility
- Reduced muscle mass
- Reduced tissue mass
- Tiredness, fatigue, or apathy
- Irritability
- In more severe cases:
- Skin may become thin, dry, inelastic, pale, and cold
- Eventually, as fat in the face is lost, the cheeks look hollow and the eyes sunken
- Hair becomes dry and sparse, falling out easily
- Sometimes, severe malnutrition may lead to unresponsiveness (stupor)
- If calorie deficiency continues for long enough, there may be heart, liver and respiratory failure
- Total starvation is said to be fatal within 8 to 12 weeks (no calorie consumption at all)

Metabolism

The word metabolism refer to all chemical reactions that occur in living organisms, including digestion and the transport of substances into and between different cells, in which case the set of reactions within the cells is called intermediary metabolism or intermediate metabolism.



Metabolism is of two types:

1. **Catabolism**: Breakdown of biomolecules in the body to release energy.
   For example: Respiration - Breakdown of glucose
2. **Anabolism**: Synthesis of biomolecules by the consumption of energy.
   For example: Photosynthesis - Synthesis of food by the plants

Food Packaging

Packaging of food is essential to make sure the food remains wholesome during the journey from processor to consumer. Packaging contains food, makes it easier to handle, and protects it from environmental conditions, such as temperature extremes, during transport. It locks out microorganisms and chemicals that could contaminate the food, and helps prevent physical and chemical changes and maintain the nutritional qualities of food. The type of food and the processing method used often influence the choice of packaging. For example, since oxygen makes fats go rancid, oils are packaged in containers that are impermeable to oxygen. On the other hand, oxygen-permeable plastic wraps allow fruits and vegetables to "breathe" and ensure that meats will maintain a vibrant red color. Metal and glass containers have traditionally been used in canning because these materials can withstand the high temperatures and changes in pressure that are involved in this processing method.

In addition to metal, glass is often used for packaging heat-sterilized foods. Glass is impermeable to oxygen and water and does not change the flavor of food. Another advantage of glass is that it is transparent, enabling the consumer to see the product inside. However, glass is not impact-resistant and is relatively heavy. Plastic, by contrast, is lightweight and unbreakable, and it has become an extremely common material for use in food packaging. Most plastics used in food packaging are heat resistant so that they can go through high-temperature sterilization processes. Plastic is made into a wide variety of shapes, including bottles, jars, trays, and tubs, as well as thin films that are used as bags and wraps.

Paper alone is not frequently used in packaging, except for certain dry foods, such as flour and sugar. However, when paper is coated with plastic or other materials to make it stronger and impermeable to water, it can be more widely used. Paperboard is often used for cartons, and plastic-coated paperboard for packaging frozen foods. Cartons and containers for shipping are usually made of corrugated cardboard.

Deterioration and Spoilage of Foods

All foods (agricultural & aquatic products) undergo varying degrees of deterioration after harvest and during storage, leading to losses in nutritional value, safety, esthetic appeal (colour, texture, flavour). Fruit, vegetables and root crops are very perishable and, if care is not taken in their harvesting, handling and transport, they will soon decay and become unfit for human consumption. Estimates of production losses in developing countries are hard to judge, but some authorities put losses of sweet potatoes, plantain, tomatoes, bananas and citrus fruit as high as they can be avoided economically, would be of great significance to growers and consumers alike. 50 percent of what is grown. Reduction in these losses, particularly if they can be avoided economically, would be of great significance to growers and consumers alike.

All fruits, vegetables and root crops are living plant parts containing 65 to 95 percent water and they continue their life processes after harvest. The post-harvest life of produce depends on the rate at which stored food reserves are used up and the rate of water loss. The changes that occur not only lead to reduced quality but can also make the product more susceptible to contamination with microorganisms. Although the microorganisms involved in produce deterioration may be of public health significance, their effects on human health are often limited since the physiological deterioration of the product often makes the product unfit for consumption. However, the potential for the growth of harmful microorganisms along with the loss of product quality make it important to not only understand the factors involved in product deterioration, but also the steps needed to maintain the best possible quality for the life of the product.

Food by nature is subject to deterioration either by chemical or microbial means. The shelf-life will be influenced by factors such as:

i. nature of the product (nutritional composition)
ii. packaging
iii. temperature

In order to optimise the storage quality and extend shelf-life of fresh and value-added products, a clear understanding of the role of the following factors in food spoilage is important:

i. chemical components in the food
ii. environmental conditions
iii. initial microbial load
iv. nature and types of micro-organisms present

Deterioration, or undesirable quality changes, may be the result of biological, microbiological, biochemical/physiological, or physical changes in the product. Factors identified as causes of deterioration usually encourage the conditions that lead to quality losses. These factors are usually the result of inadequate training of product handlers, inadequate or non-existent storage structures, unsuitable or inadequate technologies for handling and storing product, ineffective quality control, and adverse/extreme environmental conditions. In addition, time is an important factor in the spoilage of produce.

Causes of Deterioration and Spoilage

Foods are frequently classified on the basis of their stability as nonperishable, **Semi-perishable and perishable.**

1. Hermetically sealed and heat processed (e.g. canned) foods are generally regarded as non-perishable. However, they may become perishable under certain circumstances when an opportunity for recontamination is afforded following processing. Such an opportunity may arise if the can seams are faulty, or if there is excessive corrosion resulting in internal gas formation and eventual bursting of the can. Spoilage may also take place when the canned food is stored at unusually high temperatures: thermophiles spore forming bacteria may multiply, causing undesirable changes such as flat sour spoilage.
2. Low moisture content foods such as dried fruit and vegetables are classified as semi-perishable. Frozen foods, though basically perishable, may be classified as semi-perishable provided that they are properly stored at freezer temperatures.
3. The majority of foods (e.g. meat and fish, milk, eggs and most fresh fruits and vegetables) are classified as perishable unless they have been processed in some way. Often, the only form of processing which such foods receive is to be packaged and kept under controlled temperature conditions.

Chemical Factors

Deterioration may result from chemical reactions (via endogenous enzymes) or throug interactions involving one or more of the macronutrients present in food and food produc Enzymes are proteins that occur naturally in plant tissues and catalyze a number of importa biochemical reactions. Some enzyme-catalyzed reactions are beneficial while others result i quality deterioration. Examples of reactions involving endogenous enzymes include:

i. the post-harvest senescence and spoilage of fruit and vegetables;
ii. oxidation of phenolic substances in plant tissues by phenolase (leading to browning);
iii. sugar - starch conversion in plant tissues by amylases;
iv. post-harvest DE methylation of pectic substances (i.e. breakdown of structural material) in plant tissues (leading to softening of plant tissues during ripening, and firming of plan tissues during processing).
v. development of off-flavors through the breakdown of lipid components; and loss of col and undesirable browning.
vi. catalyze fermentation of sugars, breakdown of ascorbic acid, and many other deterioration reactions. Bruising, ripening, cutting, temperature, and presence of co-factors (e.g. Fe and Mg) increase the rate of derivative enzyme activity.

Physical Factors

One major undesirable physical change in food powders is the absorption of moisture as a consequence of an inadequate barrier provided by the package; this results in caking. It can occur either as a result of a poor selection of packaging material in the first place, or failure of the package integrity during storage. In general, moisture absorption is associated with increased cohesiveness.

Effect of Deterioration on Food Quality

Chemical, physical and biological changes which occur during handling, processing and storage of foods lead to deterioration in sensory and nutritional quality of foods.

Sensory Quality

Lipid Oxidation

Lipid oxidation rate and course of reaction is influenced by light, local oxygen concentration, high temperature, the presence of catalysts (generally transition metals such as iron and copper) and water activity. Control of these factors can significantly reduce the extent of lipid oxidation in foods.

Non-enzymatic browning

Non-enzymatic browning is one of the major causes of deterioration which occurs during storage of dried and concentrated foods. The nonenzymatic browning, or Maillard reaction, can be divided into three stages: a) early Maillard reactions which are chemically well-defined steps without browning; b) advanced Maillard reactions which lead to the formation of volatile or soluble substances; and c) final Maillard reactions leading to insoluble brown polymers.

Colour changes

Chlorophylls. Almost any type of food processing or storage causes some deterioration of the chlorophyll pigments. Phenophytinisation (with consequent formation of a dull olivebrown phenophytin) is the major change; this reaction is accelerated by heat and is acid catalysed. Other reactions are also possible. For example, dehydrated products such as green peas and beans packed in clear glass containers undergo photooxidation and loss of desirable colour.

Anthocyanins. These are a group of more than 150 reddish watersoluble pigments that are very widespread in the plant kingdom. The rate of anthocyanin destruction is pH dependent, being greater at higher pH values. Of interest from a packaging point of view is the ability of some anthocyanins to form complexes with metals such as Al, Fe, Cu and Sn. These complexes generally result in a change in the colour of the pigment (for example, red sour cherries react with tin to form a purple complex) and are therefore undesirable. Since metal packaging materials such as cans could be sources of these metals, they are usually coated with special organic linings to avoid these undesirable reactions.

Carotenoids. The carotenoids are a group of mainly lipid soluble compounds responsible for many of the yellow and red colours of plant and animal products. The main cause of carotenoid degradation in foods is oxidation. The mechanism of oxidation in processed foods is complex and depends on many factors. The pigments may auto-oxidise by reaction with atmospheric oxygen at rates dependent on light, heat and the presence of pro- and antioxidants.

Flavour changes

In fruit and vegetables, enzymatically generated compounds derived from long-chain fatty acids play an extremely important role in the formation of characteristic flavours. In addition, these types of reactions can lead to significant off-flavours. Enzyme-induced oxidative breakdown of unsaturated fatty acids occurs extensively in plant tissues and this yield characteristic aromas associated with some ripening fruits and disrupted tissues. The permeability of packaging materials is of importance in retaining desirable volatile components within packages, or in permitting undesirable components to permeate through the package from the ambient atmosphere.

Nutritional Quality

The four major factors which affect nutrient degradation to varying extents are light, oxygen concentration, temperature and water activity. However, due to the diverse nature of the various nutrients, chemical heterogeneity within each class of compounds and complex interactionsof the above variables, generalizations about nutrient degradation in foods will inevitably be broad ones.

Ascorbic acid is the most sensitive vitamin in foods, its stability varying markedly as a function of environmental conditions such as pH and the concentration of trace metal ions and oxygen. The nature of the packaging material can significantly affect the stability of ascorbic acid in foods. The effectiveness of the material as a barrier to moisture and oxygen as well as the chemical nature of the surface exposed to the food are important factors. For example, problems of ascorbic acid instability in aseptically packaged fruit juices have been encountered because of oxygen permeability of the package and the oxygen dependence of the ascorbic acid degradation reaction.

Food Contamination and Adulteration

Foods can become contaminated by micro-organisms (bacteria and viruses) from ma different sources during the food preparation and storage process. Cross contamination of foo a common factor in the cause of food borne illness. Preventing cross contamination is one step t help eliminate food borne illness. It is important to protect food from risk of contamination prevent food poisoning and the entry of foreign objects.

Adulteration is the act of making any commodity impure by admixture of other or bas ingredients deliberately. This admixture may corrupt the nature of the original to the extent o destroying its identity, or it may merely lower the value or effectiveness of the finished produ Adulteration of foods and beverages has been performed with the aim of increasing profits for the manufacturer or merchant. Adulteration is also designed to defraud consumers; however it ca also pose a health threat.

Food Preservation

Preservation of food is accomplished by controlling and where possible, destroying the agents of food spoilage. These agents are present in abundance not only within food but also in the environments where foods are grown, harvested, processed, stored and consumed. Raw food materials can be processed by blanching, freezing, drying, heating, pasteurizing, sterilizing canning and cooking.

Background to Food Preservation

Mankind's endeavour to ensure adequate supply of wholesome food continues today as it as been throughout the centuries. Effective methods of food preservation have been the subject of research by man since civilisation. Despite the endeavours, millions of people regularly lack sufficient food for good health while others suffer the consequences of food contamination by micro-organisms. The continuing crises in our world food supply dictate that spoilage be reduced as much as possible.

The areas of the world with the greatest nutritional deficit are those with problems of

equate food production, distribution and preservation.

Preservation processes offer benefits to the producer, the consumer and the society. The oducer is able to keep his product on the shelf longer, thus minimising economic losses. The umer can keep the product on his or her shelf longer, minimising economic and convenience sses. Society benefits by wasting less food, and in some cases, minimizing public health ards like botulism

The shelf life of many perishable foods such as meat, eggs, fish, poultry, fruits, vegetable d baked products is limited in the presence of atmospheric oxygen, growth of aerobic spoilage oorganisms and attack by insect pests. Each of these factors, alone or in conjunction with one other, result in changes in colour, flavour, odour and overall deterioration in food quality.

Many kinds of agents are potentially destructive to the agreeable and healthy aracteristics of fresh foods. Micro-organisms, such as bacteria and fungi, rapidly spoil food. zymes, which are present in all raw foods, are catalytic substances that promote degradation d chemical changes affecting especially texture and flavour. Atmospheric oxygen may react th food constituents, causing rancidity or colour changes. Equally as harmful are infestations insects and rodents, which account for tremendous losses in food stocks and a wide variety of her chemical, biochemical, or physical factors. Most preservation processes are therefore aimed destroying or inhibiting bacteria, moulds, and yeasts. There are six major methods commonly employed in food processing and preservation. These methods are based on:

1. **Temperature** Low temperature – Freezing, Cooling and Chilling High temperature – Pasteurisation, Canning, Cooking and Tyndallisation.
2. **Irradiation** – Radiolysis
3. **Moisture Reduction** – Drying and Concentration
4. **Fermentation** – Alcoholic, Acetic acid and Lactic acid.
5. **Chemical Additives** – Benzoates, sulphites, nitrites etc.
6. **Controlled /Modified Atmosphere**

Low Temperature Preservation

Storage at low temperatures prolongs the shelf life of many foods. In general, low emperatures reduce the growth rates of micro-organisms and slow many of the physical and hemical reactions that occur in foods. Low temperature preservation is based on the application Van't Hoff equation, which shows that a decrease of about 100C in temperature of a food item alves the rate of the reactions going on in the food item. Low temperatures do not sterilise foods, ut they slow down the growth of micro-organisms and decrease the rate of the chemical eactions that deteriorate foods. Because the process does not kill all types of bacteria, those that vive become active in thawing food and often grow more rapidly than before freezing. Enzymes in the frozen state remain active, although at a reduced rate. Vegetables are blanched or eated in preparation for freezing to ensure enzyme inactivity and thus to avoid degradation of flavour. In the freezing of meats, various methods are used depending on the type of meat and the ut. Pork is frozen soon after butchering, but beef is hung in a cooler for several days first to nderise the meat.

There are three methods of low temperature storage, namely:

- **Cooling:** This involves the removal of a small amount of heat from a food item. It is just a slight reduction in temperature.
- **Chilling** This involves a more pronounced reduction in temperature but it remains above

freezing temperature.

- **Freezing** This is a sharp reduction in temperature of a food item such that the food, if in liquid form will change to a solid state. This condition helps to retard the growth of micro-organisms by the cold temperature and by the lack of water, which is unavailable to them when it freezes.

This process can be slow or fast as highlighted below:

Slow Freezing

This is a condition in which ice formation is largely extra fibular in meat and extra cellular in plant tissues. Foods frozen by this method are characterised by large crystals. However, this is not often used because it is not economical and can cause physical rupture and separation of cells.

Fast Freezing

This is a condition in which ice formation is largely intrafibular in meat and intracellular in plant tissues. Foods frozen by this method are characterised by small crystals.

Refrigeration

Refrigeration is the process of lowering the temperature in a given space and maintaining it for the purpose of chilling foods, preserving certain substances, or providing an atmosphere conducive to bodily comfort. Storing perishable foods or other items under refrigeration is commonly known as cold storage. Such refrigeration checks both bacterial growth and adverse chemical reactions that occur in the normal atmosphere.

The life of many foods may be increased by storage at temperatures below 4°C (40°F). Commonly refrigerated foods include fresh fruits and vegetables, eggs, dairy products and meats. Some foods, such as tropical fruits (*e.g.*, bananas), are damaged if exposed to low temperatures. Although refrigeration retards deterioration, it cannot improve the quality of decayed food.

In mechanical refrigeration, constant cooling is achieved by the circulation of a refrigerant in a closed system, in which it evaporates to a gas and then condenses back again to a liquid in a continuous cycle. If no leakage occurs, the refrigerant lasts indefinitely throughout the entire life of the system. All that is required to maintain cooling is a constant supply of energy, or power and a method of dissipating waste heat. The two main types of mechanical refrigeration system are the compression system, used in domestic units for large cold-storage applications and for most air conditioning; and the absorption system, now employed largely for heat-operated air-conditioning.

Freezing

Freezing and frozen storage provide an excellent means of preserving the nutritional quality of foods. At sub-freezing temperatures, the nutrient loss is extremely slow for the typical storage period used in commercial trade.

The Freezing Process

The freezing of food involves lowering its temperature below 0°C, resulting in the gradual conversion of water present in the food into ice. Freezing is a crystallisation process that begins with a nucleus or a seed derived from either a non-aqueous particle or a cluster of water molecules (formed when the temperature is reduced below 0°C). This seed must be of a certain size to provide an adequate site for the crystal to begin to grow. If physical conditions are conducive to the presence of numerous seeds for crystallisation, then a large number of small ice crystals will form. However, if only a few seeds are initially available, then a few ice crystals will form and each will grow to a large size. The size and the number of ice crystals influence the final

quality of many frozen foods; for example, the smooth texture of ice cream indicates the presence of a large number of small ice crystals.

In pure water, the freezing process is initiated by lowering the temperature to slightly below 0° C, called super-cooling. As ice crystals begin to grow, the temperature returns to the freezing point. During the conversion of liquid water to ice, the temperature of the system does not change. The heat removed during this step is called the latent heat of fusion (equivalent to 333 joules per gram of water). Once all the water is converted to ice, any additional removal of heat will result in a decrease in the temperature below 0°C

The freezing of foods exhibits a number of important differences from the freezing of pure water. Foods do not freeze at 0°C. Instead, owing to the presence of different soluble particulates (solutes) in the water present in foods, most foods begin to freeze at a temperature between 0° and -5°C (32° and 23°F). In addition, the removal of latent heat in foods during freezing does not occur at a fixed temperature. As the water present in the food freezes into ice, the remaining water becomes more concentrated with solutes. As a result, the freezing point is further depressed. Therefore, foods have a zone of maximum ice crystal formation that typically extends from -1° to -4°C (30° to 25°F). Damage to food quality during freezing can be minimised if the temperature of the product is brought below this temperature range as quickly as possible.

Industrial Freezers

The rate at which heat is removed from a food during freezing depends on how fast heat can travel within the food and how efficiently it can be liberated from the surface of the food into the surrounding atmosphere. Industrial freezers remove heat from the surface of a food as rapidly as possible. There are several types of industrial freezers, including airblast tunnel freezers, belt freezers, fluidised-bed freezers, plate freezers, and cryogenic freezers.

In *air-blast tunnel freezers* and *belt freezers*, precooled air at approximately -40°C is blown over the food products. Packaged foods, such as fruits, vegetables, bakery goods, poultry, meats and prepared meals, are usually frozen in air-blast tunnels. The packages are placed on hand trucks and then rolled into the freezer tunnels. In a belt freezer, food is placed on a conveyor belt that moves through a freezing zone. Bakery goods, chicken parts and meat patties (small flat pieces) are frozen using a belt freezer.

Fluidised-bed freezers are used to freeze particulate foods such as peas, cut corn, diced carrots and strawberries. The foods are placed on a mesh conveyor belt and moved through a freezing zone in which cold air is directed upward through the mesh belt and the food particulates begin to tumble and float. This tumbling exposes all sides of the food to the cold air and minimises the resistance to heat transfer at the surface of the food.

Plate freezers are used to freeze flat products, such as pastries, fish fillets, beef patties, as well as irregular-shaped vegetables that are packaged in brick-shaped containers, such as asparagus, cauliflower, spinach and broccoli. The food is firmly pressed between metal plates that are cooled to subfreezing temperatures by internally circulating refrigerants.

Cryogenic freezing is used to freeze food at an extremely fast rate. The food is moved through a spray of liquid nitrogen or directly immersed in liquid nitrogen. The liquid nitrogen boils around the food at a temperature of -196°C (-321°F) and extracts a large amount of heat.

Quality of Frozen Foods

Frozen foods have the advantage of resembling the fresh product more closely than the same food preserved by other techniques. However, improper freezing or storage of foods may result in detrimental quality changes. When foods with high amounts of water (e.g. fish) are frozen slowly, they may experience a loss of fluid, called *drip*, upon thawing.

This fluid loss causes dehydration and nutrient loss in frozen food products.

During frozen storage, the ice crystals present in foods may enlarge in size, producing undesirable changes in texture. Freezing causes the water in food to expand and tends to disrupt the cell structure by forming ice crystals. In quick-freezing, the ice crystals are smaller, producing less cell damage than in the slowly frozen product. This phenomenon is commonly observed when the storage temperature is allowed to fluctuate. For example, ice cream stored in an automatic defrosting domestic freezer becomes sandy in texture because the ice crystals increase in size as the temperature of the system fluctuates. Some liquid foods that are frozen slowly, such as egg yolk, may become coagulated. Quick-frozen foods retain their nutrients almost intact, and the characteristics of their flavour remain virtually undiminished. Frozen foods must be stored and kept at 0°C (32°F) or below, because even partial thawing and refreezing lowers the overall quality of the product.

Improperly packaged frozen foods lose small amounts of moisture during storage, resulting in surface dehydration (commonly called *freezer burn*). Frozen meats with freezer burn have the appearance of brown paper and quickly become rancid. Freezer burn can be minimised by the use of tightly wrapped packages and the elimination of fluctuating temperatures during storage. Because of the high cost of refrigeration, frozen foods are comparatively expensive to produce and distribute.

Some Terms used in Cold Storage of Foods

- **Super cooling:** Cooling below the freezing point of a food item.
- **Eutectic mixture:** A solution from which water cannot be crystallised.
- **Freeze drying:** This is a process in which frozen food is placed in vacuum thereby causing rapid loss of water by sublimation.
- **Lypholisation:** Freeze drying
- **Freezer burn:** The drying of the surface of poorly wrapped foods due to sublimation of water (in solid state) e.g. bread.
- **Cook freeze:** Cooking, chilling and immediately freezing foods.
- **Regeneration:** A process in which food is returned to its original state for eating after chilling.
- **Chilling injury:** The result of freezing a food product under a wrong storage temperature because every food items has a specific temperature range of preservation.

Thermal Processing

Thermal processing is defined as the combination of temperature and time to eliminate a desired number of microorganisms from a food product. High temperature preservation is based on the principle that microorganisms and enzymes have optimum conditions, which if altered, inhibits their activities. It is also aimed at breaking the bonds in different food substances (glycosidic bonds in carbohydrates, peptide bonds in proteins, pi and sigma bonds in lipids) and making the nutrients available to the body.

The objective and intensity of a heat treatment is determined, to a large extent, by the nature of the food, the microorganisms that proliferate on it, the degree of contamination, the heat resistance of the microorganisms and their spores, heat transfer characteristics of the food, the condition of storage of the food as well as the pH (degree of acidity or alkalinity) of the food. Heat treatment to foods can be achieved by the following methods:

Pasteurisation

Pasteurisation is the application of heat to a food product to destroy pathogenic microorganisms, inactivate spoilage-causing enzymes and reduce/destroy spoilage microorganisms. The relatively mild heat treatment used in the pasteurisation process causes minimal changes in the sensory and nutritional characteristics of foods compared to the severe heat treatments used in the sterilisation process.

Pasteurisation is dependent on temperature and time. It can be High Temperature Short Time (HTST) or Low Temperature Long Time (LTLT). This involves either heating the food at a high temperature for a very short period or heating it at a low temperature for a long period.

For sensitive foods (e.g. milk), flash pasteurisation (HTST) is used. The temperature and time requirements of the pasteurisation process are influenced by the pH of the food. When the pH is below 4.5, spoilage microorganisms and enzymes are the main targets of pasteurisation. For example, the pasteurisation process for fruit juices is aimed at inactivating certain enzymes such as pectinestearase and polygalacturonase. The typical processing conditions for the pasteurisation of fruit juices include heating to 77°C (171°F) and holding for 1 minute, followed by rapid cooling to 7°C (45°F). In addition to inactivating enzymes, these conditions destroy any yeasts or moulds that may lead to spoilage. Equivalent conditions capable of reducing spoilage microorganisms involve heating to 65°C (149°F) and holding for 30 minutes or heating to 88°C (190°F) and holding for 15 seconds.

When the pH of a food is greater than 4.5, the heat treatment must be severe enough to destroy pathogenic bacteria. In the pasteurisation of milk, the time and temperature conditions target the pathogenic bacteria *Mycobacterium tuberculosis*, *Coxiella burnetti*, and *Brucella abortus*. The typical heat treatment used for pasteurising milk is 72°C (162°F) for 15 seconds, followed by rapid cooling to 7°C. Other equivalent heat treatments include heating to 63°C (145°F) for 30 minutes, 90°C (194°F) for 0.5 second, and 94°C (201°F) for 0.1 second. The HTST treatments cause less damage to the nutrient composition and sensory characteristics of foods and therefore are preferred over the LTLT treatments.

Since the heat treatment of pasteurisation is not severe enough to render a product sterile, additional methods such as refrigeration, fermentation, or the addition of chemicals are often used to control microbial growth and to extend the shelf life of a product. For example, the pasteurization of milk does not kill thermoduric bacteria (those resistant to heat), such as *Lactobacillus* and *Streptococcus*, or thermophilic bacteria (those that grow at high temperatures), such as *Bacillus* and *Clostridium*.

Therefore, pasteurised milk must be kept under refrigerated conditions. Liquid foods such as milk, fruit juices, beers, wines and liquid eggs are pasteurised using plate-type heat exchangers. Wine and fruit juices are normally de-aerated prior to pasteurisation in order to remove oxygen and minimise oxidative deterioration of the products. Plate-type heat exchangers consist of a large number of thin, vertical steel plates that are clamped together in a frame. Small gaskets that allow the liquid to flow between each successive plate separate the plates. The liquid product and heating medium (*e.g.*, hot water) are pumped through alternate channels and the gaskets ensure that the liquid product and heating or cooling mediums are kept separate. Plate-type heat exchangers are effective in rapid heating and cooling applications. After the pasteurisation process is completed, the product is packaged under aseptic conditions to prevent recontamination of the product.

Sterilisation

This is total destruction of life in the food item. However, this cannot be achieved without destruction of the nutrients in the food which makes the food of no value. As such, sterilisation cannot be used for food items but can only be applied as commercial sterilisation, which means the same as pasteurisation. Heat and chemicals can be used to achieve sterilisation.

Sterilisation is designed to destroy *all* viable microorganisms in foods. When foods are thermally processed, they are referred to as being *commercially sterile* i.e. the food material is free of microorganism and their spores under normal storage conditions. The most heat resistant microorganism, *Bacillus stearothermophillus* is used as the indicator organism in sterilisation operations. The presence or otherwise of this organism is a measure of the efficiency of the heat treatment given to a food item.

Tyndallisation

This is also pasteurisation but special attention is paid to the spores. This involves heating the food item to about 80 – 1000C to destroy the vegetative pathogens, then allowing it to cool to about 370C so that the spores can gamete. This cycle (heating and cooling) is repeated until satisfactory level of microbial destruction has been achieved. This method is more reliable than pasteurisation since spores are taken into consideration. However, this process is accompanied by severe nutrient losses in the food item so processed.

The Most Common Method of Food Preservation in Pakistan:

Cold Storage and Sun-drying.

Synersis:

The Separation of Liquid phase from the solid phase (mostly in Jam Jellies, Marmalades) is known as synersis.

Blanching:

Blanching is the heating of some plant food material in hot water or steam for a very short time mainly to destroy active food enzymes. It is also reduce the volume of material by expelling the air from food commodity.

The functions of Blanching:

Following are the functions of Blanching:

- It loosens the skin
- It cleans the product by removing adhering contaminants.
- It removes tissue gas from leafy vegetable.
- It helps to fix the green color.

Types of canning:

Aseptic Canning: Food is first heat processed and then filled or packed aseptically into suitable sterile containers.

Commercial Thermal Processing/Conventional Canning: Food is filled into the container which is sealed hermetically and then subjected to high temperature.

Difference b/w Cold Storage & freezer Storage:

Cold Storage: refers to the storage condition where food is held at a temperature around its freezing point.

Freezer Storage: Describes the Situation where food is held in frozen state at a temperature below freezing point.

Difference b/w spoilage &-deterioration:

Spoilage: The spoilage of foods as a result of microbial enzymatic activity.

Deterioration: Deterioration in foods caused by physical phenomena that occur during processing handling &-storage.

Difference b/w baking & barbecuting:

Baking: Cooking in an oven with dry heat (100-232oC).

Barbcuting: Direct heating over glowing, smokeless wood fire.

Difference b/w roasting &-broasting:

Roasting: Cooking by dry heat in oven or closed vessel with just a little fat.

Broasting: Pressure frying

Difference b/w Pasteurization & Sterilization:

Pasteurization: Pasteurization treatment (65oC-88oC) is applied to kill pathogenic organisms including bacteria &-yeast (Vegetative form of bacteria are killed).

Sterilization: Sterilization employs much higher temperature (100oC or above) to destroy all microbial forms (Vegetative + Spores).

Tyndallization:

Tyndallization is the process by which vegetative forms of microorganisms are killed at 80oC-100oC the germination of resistant spores (37oC) germinated spores are subsequently killed by reheating at the same temperature.

Commercially sterile foods:

For a food stuff to be declared commercially sterile all pathogenic &-target spoilage vegetative microorganisms present in food must be destroyed Additionally, microbial spores that may thrive under the subsequent handling &-storage conditions must also be eliminated.

Functioning of taste buds for primary taste:

Following are the areas:

- Sour Taste: Is most readily detected on the sides of the tongue.
- Salty Taste: On the Sides &-tips
- Sweet Taste: On the tip.
- Bitter Taste: On the back of the tongue on the pharynx.

Name of some Oxidizing/bleaching agents used in flour:

1. Benzoyl peroxide
2. Nitrogen dioxide.

Bound water:

The water which is physically or chemically bounded which can be or can not be removed; it is unavailable as solvent & it is also non-freezable.

Crude fiber:

The fiber which can not be digested by human digestive system.

Significance of digestible carbohydrate in human diet:

These provide readily available energy to the human body.

Significance of total solid in foods:

Amount of total solids determines the quality & nutritional value of a food.

Total solids important in dehydration of foods:

In dehydration we decrease available water so as to increase total solids for better quality & storage stability of food.

Composition of Nutrient agar:

Peptone, Beef extract, NaCl, Agar Agar, yeast extract.

Agar Agar is used to solidify the media:

Because most of the bacteria on earth can't utilize agar so media remain solidify.

Homogenization:

Homogenization is a process in which fat globule size is reduced to 2500 fat globules under high pressure for its uniform mixing.

Cheese:

Cheese is a fresh or ripened product obtained after coagulation and whey separation of milk.

Effect of too much sugar in Cakes:

Too much sugar causes a sticky crust & a gummy texture.

Butter:

Fat Concentrate which is obtained by churning of milk.

Composition of butter:

Fat	80-85%
Moisture	15-16%
Salt	2.5%
Curd	1%

Ice Cream:

A frozen dairy product made by suitable blend and processing of cream and other milk product together with sugar, flavor with or without stabilizer and color and with the incorporation of air during freezing.

Difference b/w sanitation &-hygiene:

Sanitation: The physical cleaning is simply called sanitation eg. Proper Drainage, Removal of Waste material etc. The reduction of microbial load up to the maximum possible level is hygiene. It includes cleaning of environment and all the working conditions etc.

Reason of some fruit juices rich in natural colors are not preserved by SO2:

Because SO2 bleaches the natural color of the fruit juices, so fruit juices rich in natural colors are preserved by Sodium benzoate.

Smoke Point:

The smoke point is the temperature at which a fat or oil gives off a thin bluish smoke.

Types of separation techniques:

1. Chromatographic technique
2. Electromigration technique.

Chromatography:

Chromatography is a dynamic physical process in which molecular components in a mixture are separated because of their different affinities for two substances referred to as phases, one being fixed or stationary and the other mobile phase.

Types of Chromatography:

1. Liquid Chromatography
2. Gas Chromatography

List of Modern Separation Techniques:

1. High Performance/Precision/Pressure liquid Chromatography (HPLC)
2. Thin Layer Chromatography (TLC)

Gas Chromatography (GC)
3 Atomic Absorption Spectrophotometer(AAS)
4 Flame Photometry(FP)
5 Fourier Transform infrared Photometer (FTIR)
6

HPLC:

HPLC is high performance/precision/pressure liquid chromatography. It is a separation technique used to separate Non-volatile compounds and high molecular compounds e.g. Antibiotics.

Gas liquid Chromatography (GLC):

Gas Chromatography is a technique for separating volatile substances by percolating a gas stream over stationary phase is liquid so called gas liquid chromatography.

Electrophoresis:

Separation of substances under high voltage (1.5kv).

Spectrophotometry:

UV-Vis light absorbed by the sample as a function of wavelength and radiated in the form of light spectrum which is detected by photocathode tube and the signal is recorded.

Thin layer Chromatography (TLC):

TLC is a separation technique in which compounds are separated between two phases namely stationary phase and mobile phase.

Lipolysis:

The breakdown of fatty material into free fatty acid and glycerol, with the heat of lipolytic enzymes, called lipolysis.

Proteolysis:

Proteolysis is the term that describes the break down of proteinaceous material.

Fermentation:

Fermentation is the anaerobic or partially anaerobic oxidation of carbohydrates. During this process enzymes elaborated by microorganism, breakdown carbohydrates or carbohydrate like material into substances that are less subject to undesirable microbial activity than the original material.

Names of industries which are included in fermentation:

Baking, brewing, wine making, vinegar manufacture.

List the fermented foods:

Yoghurt, Cheese, Sauerkraut, Pickles.

Information Technology

Stands for "Information Technology," and is pronounced "I.T." It refers to anything related to computing technology, such as networking, hardware, software, the Internet, or the people that work with these technologies. Since we live in the "information age," information technology has become a part of our everyday lives. That means the term "IT," already highly overused, is here to stay.

Computers are one of the supreme and best inventions ever made in the history of modern technology. It has brought numerous and countless advances to many different fields of studies as well as in the lives of many people. Today, computers have changed how people work and have opened new methods and means of acquiring new knowledge and skills. Computers are now being used in various fields, from education to medicine, businesses, government, science, publishing and industry.

Education

Computers have been important learning tools starting from toddlers who have computer-aided toys giving them joys to the older grade/high school/collegiate students for their research projects. Far-flung areas can now be reached and their education can now be enriched through the use of computers.

Science

All branches of science, from astronomy to zoology, depend on computers to further their knowledge on increasing the life span of man..

Computer is also important part of modern astronomy. Computers aid observational astronomers in many ways. Man's first step on the moon would not have been possible without the use of computers. Computers guide telescopes, and they control devices that measure the radiation gathered by telescopes. Astronomers also use computers to work out designs for new telescopes and to analyse data collected with telescopes. Computers have a major role in theoretical studies. A theoretical astronomer might use a computer to produce a mathematical model of the history of a star from its birth to its death.

Communications

Computers are very useful to communicate with the world. Communication was revolutionized with the advent of the Internet. We are all connected by it and can instantly chat, share information and understand what is going on clear on the other side of the world. With the amount of information available on a tool like the Internet, computers have empowered people with knowledge.

Business

Computer has changed how we do business. Computer opens new doors of opportunities and ventures. Apart from the way you do business, the computer and the Internet has also become our partner in doing business effectively. Products are sold to vast numbers of consumers, and services are provided superbly.Gone are the days of labor-intensive and manual way of inputting data through ink and paper. Now, with a few taps of keys and a few clicks of the mouse.

Government

Government offices also depend on computers for its basic needs. From simple letters to the more complicated projects are now being produced through the use of computers. Government agencies and their databases are now interlinked, making it easier for the agencies to monitor economic developments.

Used in Medicine

Computers help physicians and medical researchers discover, test and apply medical techniques in virtually every hospital in the world. Furthermore, computer technology provides an infrastructure to allow for medical ideas and knowledge to be filed and shared globally with other medical professionals

The main uses of computer in medical field

- X-rays and CT scans
- Magnetic Resonance Imaging
- Spectroscopy
- Patient Monitoring
- Surgery
- Secure Data Storage
- Diagnostic Databases
- Medical Practice Software

Computer software is used to track and project virtually all aspects of a medical practice. Patient files, profit and loss statements, and billing and insurance forms are all handled using computer software that streamlines the office work of a medical practice and allows doctors more time to spend with their patients.

Entertainment

There are two main roles of computers in the entertainment industry. First, computers virtualize everything. In other words any type of traditional entertainment can be replayed on a computer. This way nearly everything (except immovable property) can be virtualized: concerts, drama, books, movies, journals, music, radio, sports etc

The second and more significant role of computers in the entertainment industry is that they introduced completely new type of entertainment. Computer games, chats, online gaming, greeting cards, special web-sites and web applications, - all these and other electronic features have revolutionized entertainment industry completely.

Computer and the future

We have seen and continue to see the impact of computers in our lives. Trip to the moon is no longer just a dream. Robots now also play a part, not just as toys but also as handy business crews. Man has also shown that animals or maybe human beings can now be cloned. Will time come that it would be hard to say who a real man is from its counterpart robot?

History of Computer

The history of computing began with an analog machine. French philosopher, mathematician, and physicist **Blaise Pascal** invented a machine in 1642 that added and subtracted, automatically carrying and borrowing digits from column to column.

Another early mechanical computer was the Difference Engine, designed in the early 1820s by British mathematician and scientist **Charles Babbage**. Although never completed by Babbage, the Difference Engine was intended to be a machine with a 20-decimal capacity that could solve mathematical problems. Babbage also made plans for another machine, the Analytical Engine, considered to be the mechanical precursor of the modern computer. Although the Analytical Engine was never built, its key concepts, such as the capacity to store instructions. the use of punched cards as a primitive memory, and the ability to print, can be found in many modern computers.

In 1936 British mathematician **Alan Turing** proposed the idea of a machine that could process equations without human direction. The machine (now known as a Turing machine) resembled an automatic typewriter that used symbols for math and logic instead of letters. Turing intended the device to be used as a "universal machine" that could be programmed to duplicate the function of any other existing machine. Turing's machine was the theoretical precursor to the modern digital computer 'Alan Turing, is considered the "Father *of the* Modern Computer'

The Five Generataion of Computers

The history of computer development is often referred to in reference to the different generations of computing devices. Each of the five generations of computers is characterized by a major technological development that fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, and more powerful and more efficient and reliable computing devices.

First Generation (1946-1954) Vacuum Tubes

The first computers used vacuum tubes for circuitry and magnetic drums for memory, and were often enormous, taking up entire rooms. They were very expensive to operate and in addition to using a great deal of electricity, generated a lot of heat, which was often the cause of malfunctions. The Vacuum tube was developed by Lee DeForest in 1908. These computers were large in size and writing programs on them was difficult. Some of the computers of this generation were:

- **Mark I** is the *First Generation Computer*. It was the first operating machine that could *execute long computations automatically* the machine weighed 5 tons, incorporated 500 miles of wire, was 8 feet tall and 51 feet long, and had a 50 ft rotating shaft running its length, turned by a 5 horsepower electric motor.
- **ENIAC:** It was the *first general-purpose electronic computer* built in *1946* at *University of Pennsylvania, USA by John Mauchly and J. Presper Eckert*. The completed machine was announced to the public the evening of February 14, 1946. It was named *Electronic Numerical Integrator and Calculator (ENIAC).*
- **EDVAC:** It stands for *Electronic Discrete Variable Automatic Computer* and was developed in 1950
- **EDSAC:** It stands for *Electronic Delay Storage Automatic Computer* and was developed by *M.V. Wilkes at Cambridge University in 1949.*
- **UNIVAC-1**: Ecker and Mauchly produced it in 1951 by Universal Accounting Computer setup. it was the *first commercial computer* produced in the United States. It was designed principally by J. Presper Eckert and John Mauchly, the inventors of the ENIAC.

Second Generation (1955-1964) Transistors

Transistors replaced vacuum tubes and ushered in the second generation of computers. The second-generation computer used *transistors* for CPU components & *ferrite cores for main memory & magnetic disks* for secondary memory. They used high-level languages such as FORTRAN (1956), ALGOL (1960) & COBOL (1960 - 1961). I/O processor was included to control I/O operations.

Some of the computers of the Second Generation were

- **IBM 1620**: Its size was smaller as compared to First Generation computers and mostly used for scientific purpose.

- **IBM 1401**: Its size was small to medium and used for business applications.
- *CDC* **3600**: Its size was large and is used for scientific purposes.

Third Generation (1964-1977) Integrated Circuit

The development of the integrated circuit was the hallmark of the third generation of computers. Transistors were miniaturized and placed on silicon chips, called semiconductors, which drastically increased the speed and efficiency of computers. By the development of a small chip consisting of the capacity of the *300 transistors*. These ICs are popularly known as***Chips***. A single IC has many transistors, registers and capacitors built on a single thin slice of **silicon**. So it is quite obvious that the size of the computer got further reduced.

Some of the computers developed during this period were

IBM-360, ICL-1900, IBM-370, and VAX-750

Higher level language such as **BASIC** (*Beginners All purpose Symbolic Instruction Code*) was developed during this period. Computers of this generation were small in size, low cost, large memory and processing speed is very high. Very soon ICs were replaced by **LSI** (*Large Scale Integration*), which consisted about 100 components. An IC containing about 100 components is called LSI.

Fourth Generation (1977-*Present*) Microprocessors

The microprocessor brought the fourth generation of computers, as thousands of integrated circuits were built onto a single silicon chip. What in the first generation filled an entire room could now fit in the palm of the hand. The Intel 4004 chip, developed in 1971, located all the components of the computer—from the central processing unit and memory to input/output controls—on a single chip.

In 1981 IBM introduced its first computer for the home user, and in 1984 Apple introduced the Macintosh. Microprocessors also moved out of the realm of desktop computers and into many areas of life as more and more everyday products began to use microprocessors.

As these small computers became more powerful, they could be linked together to form networks, which eventually led to the development of the Internet. Fourth generation computers also saw the development of GUIs, the mouse and handheld devices.Main memory used fast semiconductors chips up to 4 M bits size. Hard disks were used as secondary memory. Keyboards, dot matrix printers etc. were developed. OS-such as MS-DOS, UNIX, Object oriented language, C++ etc were developed.

Fifth Generation (*Present and Beyond*) Artificial Intelligence

Fifth generation computing devices, based on artificial intelligence, are still in development, though there are some applications, such as voice recognition, that are being used today. The use of parallel processing and superconductors is helping to make artificial intelligence a reality. Quantum computation and molecular and nanotechnology will radically change the face of computers in years to come. The goal of fifth-generation computing is to develop devices that respond to natural language input and are capable of learning and self-organization.

Artificial Intelligence (AI),

Artificial Intelligence (AI), the study and engineering of intelligent machines capable of performing the same kinds of functions that characterize human thought.

The concept of Artificial Intelligence dates from ancient times, but the advent of digital computers in the 20th century brought AI into the realm of possibility.

Artificial Intelligence was conceived as a field of computer science in the mid-1950s. The term AI has been applied to computer programs and systems capable of performing tasks more complex than straightforward programming, although still far from the realm of actual thought. While the nature of intelligence remains elusive, Artificial Intelligence (AI) capabilities currently have far-reaching applications in such areas as information processing, computer gaming, national security, electronic commerce, and diagnostic systems.

The search for Artificial Intelligence (AI) goes well beyond computer science and involves cross-disciplinary studies in such areas as cognitive psychology, neuroscience, linguistics, cybernetics, information theory, and mechanical engineering, among many others. The search for Artificial Intelligence (AI) has led to advancements in those fields, as well.

Future of Artificial Intelligence

Building intelligent systems—and ultimately, automating intelligence—remains a daunting task, and one that may take decades to fully realize. Artificial Intelligence research is currently focused on addressing existing shortcomings, such as the ability of Artificial Intelligence systems to converse in natural language and to perceive and respond to their environment. However, the search for Artificial Intelligence has grown into a field with far-reaching applications, many of which are considered indispensable and are already taken for granted. Nearly all industrial, governmental, and consumer applications are likely to utilize Artificial Intelligence capabilities in the future.

How Computers Works

Computer is a machine that performs tasks, such as mathematical calculations or electronic communication, under the control of *a set of* instructions called a program. Programs are retrieved and processed by computer electronics, and the program results are stored or routed to output devices, such as video display monitors or printers. Computers are used to perform a wide variety of activities with reliability, accuracy and speed.

How Computers Work

The physical computer and its components are known as hardware. Computer hardware includes the memory that stores data and program instructions; the central processing unit (CPU) that carries out program instructions; the input devices, such as a keyboard or mouse, that allow the user to communicate with the computer; the output devices, such as printers and video display monitors, that enable the computer to present information to the user; and buses (hardware lines or wires) that connect these and other computer components. The programs that run the computer are called software. Software generally is designed to perform a particular type of task—for example, to control the arm of a robot to weld a car's body, to write a letter, to display and modify a photograph, or to direct the general operation of the computer.

Logically a computer system consists of two parts which are:

1) Hardware
2) Software

"The Physical components of a computer are called hardware."

The parts of a computer, which we can touch, and feel, are called hardware parts. Hardware components of a computer are properly designed and manufactured by different electronic companies. The Hardware components of a computer enable the user to communicate with the computer and to get result of input data from it. A Computer is the combination of different hardware goods.

Software:

A computer cannot solve any problem itself; we give instructions to it for solving problems.

The set of programs (set of statements in any computer language) to solve a problem or to control the hardware of a computer is called software."

The Software are logical parts of a computer. We cannot touch to these parts of a computer but can feel them. With the help of software the user of the computer can easily work on it. The Software also manages the hardware resources of a computer.

Computer Hardware

Computer hardware refers to the physical parts of a computer and related devices. Internal hardware devices include motherboards, hard drives, and RAM. External hardware devices include monitors, keyboards, mice, printers, and scanners.

The internal hardware parts of a computer are often referred to as components, while external hardware devices are usually called peripherals. Together, they all fall under the category of computer hardware.

Hardware represents the physical and tangible components of the computer, i.e., the components that can be seen and touched.

Examples of Hardware are following:

- **Input devices**-- keyboard, mouse, etc.
- **Output devices**-- printer, monitor, etc.
- **Secondary storage devices**-- Hard disk, CD, DVD, etc.
- **Internal components**-- CPU, motherboard, RAM, etc.

Input Device

Input devices, such as a keyboard or mouse, permit the computer user to communicate with the computer. Other input devices include a joystick, a rodlike device often used by game players; a scanner, which converts images such as photographs into binary information that the computer can manipulate; a light pen, which can draw on, or select objects from a computer video display by pressing the pen against the display surface; a touch panel, which senses the placement of a user's finger; and a microphone, used to gather sound information.

Keep in mind *that* drives such as a CD-ROM, DVD, and aFloppy diskette drive may be capable of sending the computer information, but they are *not* input devices. These devices are considered storage devices.

Q: Write a note, how data is stored on a 'Hard Disk' (CSS-2018)

Computer data storage is a complex subject, but it can be broken down into three basic processes. First, data is converted to simple numbers that are easy for a computer to store. Second, the numbers are recorded by hardware inside the computer. Third, the numbers are organized, moved to temporary storage and manipulated by programs, or software.

Binary Numbers

Every piece of data in a computer is stored as a number. For example, letters are converted to numbers, and photographs are converted to a large set of numbers that indicate the color and brightness of each pixel. The numbers are then converted to binary numbers. Conventional numbers use ten digits, from 0-9, to represent all possible values. Binary numbers use two digits, 0 and 1, to represent all possible values. The numbers 0 through 8 look like this as binary numbers: 0, 1, 10, 11, 100, 101, 110, 111, 1000. Binary numbers are very long, but with binary numbers any value can be stored as a series of items which are true (1) or false (0), such as North/South, Charged/Uncharged, or Light/Dark.

Primary Data Storage

The main data storage in most computers is the hard disk drive. It is a spinning disk or disks with magnetic coatings and heads that can read or write magnetic information, similar to how cassette tapes work. In fact, early home computers used cassette tapes for data storage. Binary numbers are recorded as a series of tiny areas on the disc which are magnetized either north or south. Floppy disks, ZIP drives, and tapes all use magnetism to record binary numbers. The data on tapes and disks can be destroyed if they come too close to magnets.

Other Data Storage

Some new laptop computers use solid state drives for primary data storage. These have memory chips, similar to memory chips in USB keys, SD cards, MP3 players, cell phones and so on. Binary numbers are recorded by charging or not charging a series of tiny capacitors in the chip. Electronic data storage is more rugged than magnetic data storage, but after several years the capacitors lose their ability to store electrical charges.

CDs and DVDs use optics to store binary numbers. As the disk spins, a laser is either reflected or not reflected by a series of tiny mirrored sections on the disk. Writable disks have a reflective layer that can be changed by the laser in the computer. Disks are long-lasting, but fragile; scratches on the plastic layer prevent the laser from correctly reading reflections from the aluminum layer.

Temporary Data Storage

Drives, disks and USB keys are used for long term data storage. Within the computer there are many areas for short term electronic data storage. Small amounts of data are temporarily stored in a keyboard, printer and sections of the motherboard and processor. Larger amounts of data are temporarily stored in the memory chips and video card. Temporary data storage areas are designed to be smaller but faster than long term storage, and do not retain the data when the computer is turned off.

Organizing Data Storage

Data is stored as lots of binary numbers, by magnetism, electronics or optics. While the computer is operating, data is also stored in many temporary locations. Software is responsible for organizing, moving and processing all those numbers. The computer's BIOS contains simple instructions, stored as data in electronic memory, to move data in and out of different storage locations and around the computer for processing. The computer's operating system, for example, contains instructions for organizing data into files and folders, managing temporary data storage, and sending data to application programs and devices such as printers. Finally, application programs process the data.

The Central Processing Unit (CPU) (CSS 1996)

Information from an input device or memory is communicated **via** the bus to the CPU, which is the part of the computer that translates commands and runs programs. The CPU is a microprocessor chip- it is a single piece of silicon containing millions of electrical components. Information is stored in a CPU memory location called a register. Registers can be thought of as the CPU's tiny scratchpad, temporally storing instructions or data. When a program is run, one register called the program counter keeps track of which program instruction comes next. The CPU's control unit coordinates and *times* the CPU's functions and retrieves the next instruction from memory. In a typical sequence, the CPU locates the next instruction in the appropriate memory device. The instruction *then* travels along the bus from the computer's memory to the CPU, where it is stored in a special instruction register. *Meanwhile*, the program counter is incremented to prepare for the next instruction. The current instruction is analyzed by a detector, which determines what *the* instruction will do. Any data the instruction needs are retrieved via the

s and placed in the CPU's registers. The CPU executes the instruction, and the results are ed in another register or copied to *specific* memory locations.

utput Device

Once the CPU has executed the program instruction, the program may request that formation be communicated to an output device, such as a video display monitor or a flat liquid stal display. Other output devices are printers, overhead projectors, videocassette recorders, d speakers.

Keep in mind *that* drives such as a CD-ROM, DVD, and a Floppy diskette drive may be capable of sending the computer information, but they are *not* output devices. These devices are considered storage devices.

Device

Visual Display Unit: The most popular input/output device is the Visual Display Unit VDU). It is also called the *monitor*. A Keyboard is used to input data and Monitor is used to isplay the input data and to receive massages from the computer. A monitor has its own box hich is separated from the main computer system and is connected to the computer by cable. In me systems it is compact with the system unit. It can be *color* or *monochrome*

Printers:

It is an important output device which can be used to get a printed copy of the processed ext or result on paper. There are different types of printers that are designed for different types of applications.Depending on their speed and approach of printing

Categories of printers:

Broadly there are two categories of printers:

- **Impact printers:** Impact printers use the familiar typewriter approach of hammering a typeface against the paper and inked ribbon. *Dot-matrix printers* are of this type.
- **Non-impact printers:** Non-impact printers do not hit or impact a ribbon to print. They use *electro-static chemicals* and *ink-jet technologies .Laser printers* and *Ink-jet printers* are of this type. This type of printers can produce *color printing* and *elaborate graphics*.

Plotter

The plotter is a computer printer for printing vector graphics. In the past, plotters were used in applications such as computer-aided design, though they have generally been replaced with wide-format conventional printers. A plotter gives a hard copy of the output. It draws pictures on paper using a pen. Plotters are used to print designs of ships and machines, plans for buildings and so on.

Difference between an Input and Output Device

To understand the difference between an input and output device, you must understand the difference between input and output. Any information or data that's entered or sent to the computer to be processed is considered input and anything that is displayed from the computer is output. Therefore, an input device such as a computer keyboard is capable of having information sent to the computer, but does not display (output) any information. An output device such as a computer printer can print information from the computer but does not send any information (input) to the computer.

Bit and Byts

Most components in a computer can take one of two states: on/off; positive/negative harge; *etc*. We can represent these states by the binary digits 0 (off) and 1 (on). Each binary digit (or **bit**) has two possible values (0, 1), but groups of binary digits can be used to represent larger numbers. Most computer systems use groups of 8 bits as their basic building blocks. These 8-bit groups are referred to as *bytes*.

Computer Memory

To process information electronically, data are stored in a computer *in the form of* binary digits, or bits, each having two possible representations (0 or 1). If a second bit is added to a single bit of information the number of representations is doubled, **resulting in** four possible combinations: 00,01,10, or 11. A third bit added to this two-bit representation again doubles the number of combinations, *resulting in* eight possibilities: 000, 001,010, 011, 100,101, 110, or 111. **Each time** a bit is added, the number of possible patterns is doubled. Eight bits is called a byte; a byte has 256 combinations of 0s and 1s.

A byte is a useful quantity in which to store information because it provides enough possible patterns to represent the entire alphabet, in lower and upper cases, as well as numeric digits, punctuation marks, and several character-sized graphics symbols, including non-English characters such as p. A byte also can be interpreted as a pattern that represents a number between 0 and 255.

- A kilobyte—1,024 bytes—can store about 1,000 characters
- A megabyte can store about 1 million characters
- A gigabyte can store about 1 billion characters
- A terabyte can store about 1 trillion characters.

Difference between bits and bytes (CSS 2008)

Bits, kilobits (Kbps), and megabits (Mbps) are most often used to measure data transfer speeds. This may refer to how fast you are downloading a file, or how fast your Internet connection is. For example, if you are downloading a file on cable modem, your download speed might be 240Kbps. This is much faster than a dial-up modem, which maxes out at 56Kbps.

Bytes, on the other hand, are used to measure data storage. For example, a CD holds 700MB (megabytes) of data and a hard drive may hold 250GB (gigabytes). The other important difference is that **bytes contain eight bits of data**. Therefore, a 240Kbps download is only transferring 30KB of data per second. However, kilobytes per second is not as commonly used as kilobits per second for measuring data transfer speeds. After all, using kilobits per second (Kbps) makes your connection sound eight times faster!

It is important to know that bytes are abbreviated with a capital B, where as bits use a lowercase b. Therefore, Mbps is megabits per second, and MBps is megabytes per second. So 8Mbps is equal to 1MBps.

How Memory Works

Computer memory maybe divided into two broad categories known as

1. Internal Memory
2. External Memory

Internal Memory

Internal memory operates at the highest speed and can be accessed directly by the Cenetral Processing Unit (CPU) the main electronic circuitry within a computer that processes information. Internal memory is contained on computer chips and uses alectronic circuits to store information. **External Memory**

External memory consists of storage on peripheral devices that are slower than internal memories but offer lower cost and the ability to hold data after the computer's power has been turned off. External memory uses inexpensive mass storage devices such as magnetic hard drives.

Read Only Memory (ROM)

Internal memory also known as random access memory (RAM) or read only memory (ROM). Information stored in RAM can be accessed in any order or maybe erased or written over. Information stored in ROM may be random-access in that it maybe accessed in any order but the information recorded on ROM usually permanent and can not be erased or written over.

Internal RAM (Random Access Memory) (CSS 2000)

The Random Access Memory (RAM) is made up of small memory chips that form a memory module. These modules are installed in the RAM slots on the motherboard of the computer.

Computer programs are stored in a disk which is referred to as the hard disk. Typically hard disks are located inside the computer. When you want to use a program such as a word processor, you instruct the computer to load this program.

In a matter of seconds the computer reads the program from the disk and starts loading (copying) it into the RAM.

The more RAM your computer has, the more data can be loaded from the hard drive into the RAM, which can effectively speed up your computer. In fact, adding RAM can be more beneficial to your computer's performance than upgrading the processor. Nowadays, 4GB RAM is a standard on all computers.

If the computer's power supply is cut off, the information held in the RAM is lost. For this reason, data stored in RAM, which is required for future use, has to be stored on secondary storage devices such as USB (Universal Serial Bus) flash drives and hard disks. USB flash drives are sometimes referred to as USB pen disks.

Storage Devices

As indicated above, the internal memory (RAM) is temporary, and therefore information has to be stored on permanent media (hard-disks or USB flash drives) referred to as secondary or backing storage

Flash Memory

This is a solid-state, nonvolatile, rewritable memory that functions like RAM and a hard disk combined. If power is lost, all data remains in memory. Because of its high speed, durability, and low voltage requirements, it is ideal for digital cameras, cell phones, printers, handheld computers, pagers and audio recorders.

Comparison *of* RAM *and* ROM (CSS 2008/ 2018)

Read-only memory or **ROM** is a form of data storage in computers and other electronic devices that can not be easily altered or reprogrammed. RAM is referred to as volatile memory and is lost when the power is turned off whereas ROM in non-volatile and the contents are retained even after the power is switched off.

Random Access Memory or **RAM** is a form of data storage that can be accessed randomly at any time, in any order and from any physical location in contrast to other storage devices, such as hard drives, where the physical location of the data determines the time taken to retrieve it. RAM is measured in megabytes and the speed is measured in nanoseconds and RAM chips can read data faster than ROM.

	RAM	ROM
Definition:	Random Access Memory or RAM is a form of data storage that can be	Read-only memory or ROM is also a form of data storage that can not be easily altered or reprogrammed.Stores instuctions that are

	accessed randomly at any time, in any order and from any physicallocation. Allowing quick access and manipulation.	not nescesary for re-booting up to make the computer operate when it is switched off.They are hardwired
Stands for:	Random Access Memory	Read-only memory
Use:	RAM allows the computer to read data quickly to run applications. It allows reading and writing	ROM stores the program required to initially boot the computer. It only allows reading.
Volatility:	RAM is volatile i.e. its contents are lost when the device is powered off	It is non-volatile i.e. its contents are retained even when the device is powered off.
Types:	The two main types of RAM are static RAM and dynamic RAM.	The types of ROM include PROM, EPROM and EEPROM

Cache Memory

A cache stores recently-used information in a place where it can be accessed extremely fast. For example, a Web browser like Internet Explorer uses a cache to store the pages, images, and URLs of recently visited Web sites on hard drive. With this neat strategy, when you visit a page you have recently been to, the pages and images don't have to be downloaded to your computer all over again. Because accessing your computer's hard disk is much faster than accessing the Internet, caching Web sites can speed up Web browsing significantly. Most Web browsers allow you to adjust the size of the cache in browser preferences.

Cache memory is random access memory (RAM) that a computer microprocessor can access more quickly than it can access regular RAM (Main memory). As the microprocessor processes data, it looks first in the cache memory and if it finds the data there (from a previous reading of data), it does not have to do the more time-consuming reading of data from larger memory

Cache memory is sometimes described in levels of closeness and accessibility to the microprocessor. An L1 cache is on the same chip as the microprocessor. (For example, the PowerPC 601 processor has a 32 kilobyte level-1 cache built into its chip.) L2 is usually a separate static RAM (SRAM) chip. The main RAM (Main memory) is usually a dynamic RAM (DRAM) chip.

Difference between RAM and Cache Memory (CSS 2008)

Memory of a computer is organized in to a hierarchy and they are organized considering the time taken to access them, cost and capacity. RAM and cache memory are two members in this memory hierarchy. RAM (Random Access Memory) is the primary memory used in a computer. Its individual memory cells can be accessed in any sequence, and therefore it is called the random access memory. RAMs are divided in to two categories as Static RAM (SRAM) and Dynamic RAM (DRAM). Cache memory is a special memory used by the CPU (Central Processing Unit) of a computer for the purpose of decreasing the average time required to access memory.

In the memory hierarchy, cache memory is the closer memory to the CPU when compared with the RAM. Cache memory is much faster and also expensive when compared with the RAM. But the capacity of the RAM memory is larger than the capacity of the cache memory.

Further, the cache memory is also organized as a hierarchy as L1, L2 and L3 caches that differ in speed, cost and capacity.

Registers

In a computer, a register is one of a small set of data holding places that are part of a computer processor. A register may hold a computer instruction, a storage address, or any kind of data (such as a bit sequence or individual characters). Some instructions specify registers as part of the instruction.

For example, an instruction may specify that the contents of two defined registers be added together and then placed in a specified register. A register must be large enough to hold an instruction **For example**, in a 32-bit instruction computer, a register must be 32 bits in length. In some computer designs, there are smaller registers - **For example,** *half-registers* - for shorter instructions. Depending on the processor design and language rules, registers may be numbered or have arbitrary names.

External memory

External memory can generally be classified as either magnetic or optical, or a combination called magneto-optical.

Magnetic storage

Magnetic storage uses different patterns of magnetization on a magnetically coated surface to store information. Magnetic storage is non-volatile. The information is accessed using one or more read/write heads which may contain one or more recording transducers.

A read/write head only covers a part of the surface so that the head or medium or both must be moved relative to another in order to access data. In modern computers, magnetic storage will take these forms:

- **Magnetic disk**
  - **Floppy disk**, used for off-line storage *(Is a flexible plastic disk coated with magnetic material and covered by a protective jacket, used mainly by computers to store data magnetically.)*
  - **Hard disk drive**, used for secondary storage *(Is a memory device that is covered with a magnetic coating on which digital information is stored.)*

Magnetic tape data storage, used for tertiary and off-line storage

In early computers, magnetic storage was also used for primary storage in a form of magnetic drum, or core memory, core rope memory, thin-film memory, twistor memory or bubble memory. Also unlike today, magnetic tape was often used for secondary storage.

Optical Storage

Optical storage, the typical Optical disc, stores information in deformities on the surface of a circular disc and reads this information by illuminating the surface with a laser diode and observing the reflection. Optical disc storage is non-volatile. The deformities may be permanent (read only media), formed once (write once media) or reversible (recordable or read/write media). The following forms are currently in common use:

- CD, CD-ROM, DVD, BD-ROM: Read only storage, used for mass distribution of digital information (music, video, computer programs)
- CD-R, DVD-R, DVD+R BD-R: Write once storage, used for tertiary and off-line storage
- CD-RW, DVD-RW, DVD+RW, DVD-RAM, BD-RE: Slow write, fast read storage, used for tertiary and off-line storage
- Ultra Density Optical or UDO is similar in capacity to BD-R or BD-RE and is slow write fast read storage used for tertiary and off-line storage

Comparison of Primary and Secondary Memory

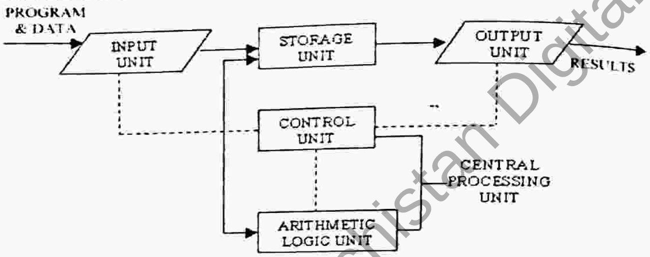
Primary Memory	**Secondary Memory**
These are semiconductor memories.	These are magnetic and optical memories.
They are characterized as volatile random access memories (RAM) or non-volatile memories (ROM).	They are non-volatile
They contain program and data that is currently being used by micro processor	These are used to for bulk storage
These memories are fast enough to interact with the microprocessor.	Slower than primary memories.
Also known as Main Memory	Also known as Backup Memory or Auxiliary Memory. E.g. Tapes, Floppies, Hard Discs, CD ROMs, DVDs

***Q:* Draw a basic computer block diagram and briefly explain the function of each part.** (CSS-2017)

Block diagram of computer:

A computer takes help of a different device to perform a different job. A computer can process a large volume of data and produce a desirable result. When we get inside working of computer we find that there are different hardware components (categorized under different types or unit) playing their roles to support the overall processing of a computer system? The figure below explains the block diagram of computer system.

ternal Parts of the Central Processor



A computer as shown in *above fig* performs basically five major operations or functions irrespective of their size and make. These are

1) It accepts data or instructions by way of input
2) It stores data
3) It can process data as required by the user
4) It gives results in the form of output
5) It controls all operations inside a computer. We discuss below each of these operations.

rithmetic Logical Unit (ALU) (CSS 2000)

After you enter data through the input device it is stored in the primary storage unit. The ctual processing of the data and instruction are performed by Arithmetic Logical Unit. The ajor operations performed by the ALU are addition, subtraction, multiplication, division, logic nd comparison. Data is transferred to ALU from storage unit when required. After processing e output is returned back to storage unit for further processing or getting stored

Control Unit (CU) (CSS 2000)

The next component of computer is the Control Unit, which acts like the supervisor eeing that things are done in proper fashion. Control Unit is responsible for co ordinating various perations using time signal. The control unit determines the sequence in which computer programs and instructions are executed. Things like processing of programs stored in the main memory, interpretation of the instructions and issuing of signals for other units of the computer to execute them. It also acts as a switch board operator when several users access the computer imultaneously. Thereby it coordinates the activities of computer's peripheral equipment as they perform the input and output.

Software (CSS 1991/2000/ 2002)

The programs that run the computer are called software. Software generally is designed to perform a particular type of task—for example, to control the arm of a robot to weld a car's body, to write a letter, to display and modify a photograph, or to direct the general operation of the computer

There are two major types of software: systems software and application software.

System Software

System Software is set of programs to control and manage the operations of computer hardware. It controls the usage and allocation of different hardware components. It enables application programs to execute properly. It controls the basic operations as follows:

- Saving data on disk
- Making computer to work for us
- Printing a document etc.

Examples of System Software

Some examples of system software are as follows:

- Operating System
- Utility Programs
- Device Drivers

Application Software

Application software is used to perform various applications on the computer. It helps a computer user to perform specific tasks. People use application software according to their needs. It is also known as *application package.*

Categories of Application Software

The main categories of application software are as follows:

a) Customized Software

Customized software is a type of application software that is designed for a particular customer or organization. It is developed to meet the exact requirements of a particular customer or organization. A Customized software can be developed by single programmer or a team of programmers. The cost of customized software is more than packaged software.

Example

- A Software that is developed for a particular university is an example of customized software.

b) Package Software

Package software is a type of application software that is developed for sale to the general public. It is also known as **off – the – shelf** software. It enables the people to perform daily activities. Package software is normally developed by expert programmers.

Examples

Some examples of package software are as follows:

- Word processor such as MS word.
- Spreadsheet such as MS excel and Lotus 123 etc.
- Database software such as MS access and Oracle etc.

Comparison between System Software and Application Software

System Software	Application Software
It is general-purpose software	It is specific purpose software
It is used to manage computer resources.	It is used to solve particular problems.
It executes all the time in computer	It executes as and when required.
The number of system software is less than application software.	The number of application software is much more than system software
System software is essential for computer to work	Application software is not essential for a computer to work

Utility Software

Utility software is a kind of system software designed to help analyze, configure, optimize and maintain the computer. A single piece of utility software is usually called utility or tool.

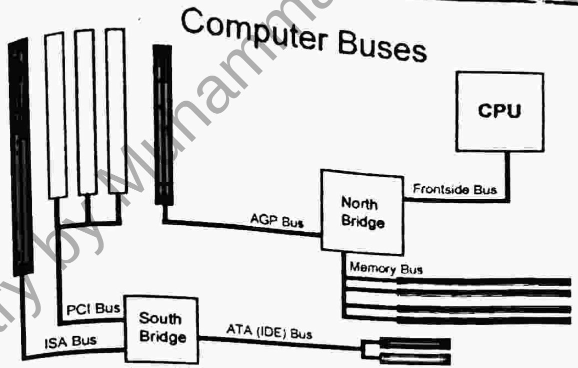
Utility software should be contrasted with application software, which allows users to do things like creating text documents, playing games, listening to music or surfing the web. Rather than providing these kind of user- oriented or output – oriented, functionality, utility software usually focuses on how the computer infra structure (*including* the computer hardware, OS, application software and data storage).

Most utilities are highly specialized and designed to perform only a single task or also some utility suites that combine several features in one software.
Most major OS come with several pre- installed utilities.

***Q:* Name three basic buses employed in a computer and explain what each is used for.** (CSS-2017)

Bus

When referring to a computer, the **bus** also known as the **address bus, data bus,** or local **bus** is a data connection between two or more devices connected to the computer. For example, a bus enables a computer processor to communicate with the memory or a video card to communicate with the memory.



The bus contains multiple wires (signal lines) that contain addressing information that describes the memory location of where the data is being sent or where it is being retrieved. Each wire in the bus carries a single bit of information, which means the more wires a bus has the more information it can address. For example, a computer with a 32-bit address bus can address 4 GB of memory, and a computer with a 36-bit bus can address 64 GB of memory.

A bus is capable of being a parallel or serial bus and today all computers utilize two bus types, an **internal bus** or local bus and an **external bus,** also called the **expansion bus.** An internal bus enables communication between internal components such as a video card and memory. An external bus is capable of communicating with external components such as a USB or SCSI device.

A computer or device's **bus speed** is listed in MHz, e.g., 100 MHz FSB. The throughput of a bus is measured in bits per second or megabytes per second.

Examples of computer buses

A-F	G-N	O-P	P-Z
AGP ATA EISA eSATA ExpressCard Firewire FSB	HyperTransport IDE ISA MCA NuBus	PATA PC Card PCI PCIe PCMCIA	SATA SBus SCSI Thunderbolt USB VLB VME Bus

Most popular computer bus

Today, many of the buses listed above are no longer used or are not as common. Below is a listing of the most buses and how they are used with a computer.

- **eSATA and SATA** - Computer hard drives and disc drives.

- **PCIe** - Computer expansion cards and video cards.
- **USB** - Computer peripherals.

Three Types of Buses

A computer sends several kinds of electronic signals back and forth among its various components. For efficiency, separate paths on the motherboard called buses each carry only one kind of signal; this boosts the computer's speed and simplifies its operation. While PC motherboards have different buses for expansion cards and external devices, all computers have three fundamental buses: Control, Instruction and Address. The whole system operates through these buses.

Control Bus

The motherboard's control bus manages the activity in the system. The control bus, like the other buses, is simply a set of connections among the parts in the computer. All parts "agree to recognize" that if one connection carries a voltage and the next one does not, it means that the central processor reads from memory. If the connections reverse roles, the processor writes to memory. Other connections deal with the "chunking" of data 8, 16, 32 or 64 bits at a time. Still others determine if data is being shuttled to the central processor from memory or the keyboard. This signaling system prevents data from going to the wrong place.

Data Bus

The data bus acts as a conduit for data from the keyboard, memory and other devices. It passes information at speeds up to billions of characters per second. The central processor reads the data, performs calculations, and moves new data back to memory, the hard drive and other locations. The control bus determines which direction the data is moving.

Address Bus

The computer must be able to access every character of memory rapidly, so every character has its own address number. The central processor specifies which addresses it wants to read or write and the address bus carries this information to a memory controller circuit, which locates and fetches the information. Some locations, called random-access memory, hold program instructions and temporary calculation results. Other locations point to the hard drive, mouse and keyboard. The control bus specifies which of these two sets of addresses become active for a particular memory operation.

Differences *between* Computer Hardware *and* Software (CSS 2008)

	Hardware	Software
Definition:	Devices that are required to store and execute (or run) the software.	Collection of instructions that enables a user to interact with the computer. Software is a program that enables a computer to perform a specific task, as opposed to the physical components of the system (hardware).
Types:	Input, storage, processing, control, and output devices.	System software, Programming software, and Application software.
Examples:	CD-ROM, monitor, printer, video card, scanners, label makers, routers, and modems.	Quickbooks, Adobe Acrobat, Winoms-Cs, Internet Explorer , Microsoft Word , Microsoft Excel
Function:	Hardware serve as the delivery system for software solutions. The hardware of a computer is infrequently changed, in comparison with software and data, which are "soft" in the sense that they are readily created, modified, or erased on the comput	To perform the specific task you need to complete. Software is generally not needed to for the hardware to perform its basic level tasks such as turning on and reponding to input.
Inter dependency:	Hardware starts functioning once software is loaded	To deliver its set of instructions, Software is installed on hardware.
Failure:	Hardware failure is random. Hardware does have increasing failure at the last stage.	Software failure is systematic. Software does not have an increasing failure rate.
Durability:	Hardware wears out over time.	Software does not wear out over time. However, bugs are discovered in software as time passes.
Nature:	Hardware is physical in nature	Software is logical in nature.

Q: Describe various types of computers classified on the basis of size, memory, capacity and speed. (CSS-2017)

Classification of Computers by Size

Computers can be grouped into six major categories according to size, with each excelling at specific functions.

- Supercomputers
- Mainframes
- Mini-computers
- Servers
- Personal computers
- Embedded systems

Generally, larger categories of computers have higher processing speeds while smaller ones are a better experience for personal computing.

Supercomputers

A computer or array of computers that act as one collective machine capable of processing enormous amounts of data. **Supercomputers** are used for very complex jobs such as nuclear research or forecasting weather patterns.

The size of a supercomputer can differ widely, depending on how many computers make up the supercomputer. A supercomputer could be made up of 10, 100, 1000, or more computers, all working together. As of 2016, the largest supercomputer is the Sunway TaihuLight in China. It consists of 40,960 RISC processors, each with 256 cores, totaling 10,649,600 cores. The Sunway TaihuLight is capable of 93 petaflops of processing power and uses a custom operating system, called Sunway RaiseOS.

The Top Supercomputer Every Year From 2008-2017

Year	Name of Supercomputer	Manufacturer	Speed in PFLOPS
2008	Roadrunner	IBM - USA	1.105
2009	Jaguar	Cray - USA	1.759

2010	Tianhe - 1A	NUDT - China	2.566
2011	K Computer	Fugitsu - Japan	10.51
2012	Titan	Cray - USA	17.59
2013	Tianhe - 2	NUDT - China	33.86
2014	Tianhe - 2	NUDT - China	33.86
2015	Tianhe - 2	NUDT - China	33.86
2016	Sunway TaihuLight	NSC -China	93.01
2017	Sunway TaihuLight	NSC -China	93.01

Mainframes

Mainframe computers are large and powerful machines. However, they fall short in terms of the computation ability seen in supercomputers. They are like big file servers, enabling multiple users from nearby and remote locations to access resources at the same time. Also known as big iron, these systems can handle massive amounts of data going in and out simultaneously.This makes them popular with businesses.

They are also resilient as they are capable of operating for over 10 years without failing Users access the mainframe using terminals or personal computers. This can happen within the same building or via wide area network (WAN).

Most of these systems run the z/OS (operating system) on 64bit architecture.

Minicomputers

Minicomputers are general purpose devices without the monumental expenses associated with a larger system. Their processing power is below that of mainframe systems but above the capabilities of personal computers.

Also known as mid-range computers, these became popular in the late 1960s but have become almost extinct because of the popularity of personal computers. The latter can now perform most of the tasks reserved for minis.

The first minicomputer was unveiled in 1967 by Digital Equipment Corporation and was followed later by designs from IBM and other companies.

They became popular for control related functions as opposed to computing prowess. Over the years, their usage was limited to dedicated control assignments in mid-range organizations.

Microcomputers/Personal Computers

Microcomputers are the smallest, least expensive and the most used computer systems. They have a small memory, less processing power, are physically smaller, and permit fewer peripherals compared to super and mainframe computers. They are more commonly known as personal computers or simply PCs. The term was initially used to refer to IBM compatible computers.

They became popular in the 70s and 80s, at the dawn of the microprocessor chips. These chips meant that a machine used by one individual was now feasible.

The advent of PCs meant cheaper alternatives to more expensive and centralized systems. They were more affordable for office use and created cheaper networking environments. By the mid-1990s, they became the de facto computer of choice for offices and homes. The last 20 years have seen the proliferation of even smaller systems.

This signaled the start of the mobile age, which continued to go with the trend of smaller devices as the new century progressed. This ultimately gave birth to wearable computers and gadgets.

sktop Computers

sktop computers are made up of separate components such as:

- The system unit; a rectangular case that contains important parts like the motherboard, microprocessor, memory modules, disk drive, and optical drive.
- The monitor.
- A mouse.
- A keyboard.

Mobile Computers

Mobile devices have become the norm in recent years. Most users opt for laptops and blets due to ease of use on the go, and battery power.

rticular features that make mobile systems a favorite include:

- Extended battery use.
- Wi-Fi capabilities.
- Mobility.

The most common types of mobile computers include:

- Laptop computers.
- Tablets.
- Smartphones.
- Personal Digital Assistants (PDA).

Wearable Gadgets

Like the term suggests, wearable computers, or simply wearables, are miniature devices that are designed to be worn or attached onto your body Wearables are designed to function as smart devices similar to smartphones. They typically provide specific functions like health monitoring. Whereas general purpose wearables offer a fuller computing experience that includes reading emails, the lesser systems will ship as embedded devices capable of minimal functions. Examples of these devices include smartwatches, smartglasses, smartclothes, and smartshoes.

Computer Programming Languages

There are two major types of programming languages. These are Low Level Languages and High Level Languages. Low Level languages are further divided into Machine language and Assembly language.

Low level languages

The term low level means closeness to the way in which the machine has been built. Low Level languages are machine oriented and require extensive knowledge of computer hardware and its configuration. The low level languages are:

1. Machine Language
2. Assembly Language

Machine Language

Machine Language is the language of the computer and is the only language that is directly understood by the computer. We also call it machine code and it is written as strings of 1's and 0's. It is on this basis that the computer is designed. When this sequence of codes is fed to the computer, it recognizes the codes and converts it in to electrical signals needed to run it. For example, a program instruction may look like this:

```
1011000111101
```

It is not an easy language it is considered to the first generation language. It is also difficult to debug the program written in this language.

Assembly Language

It is the first step to improve the programming structure. Assembly Language has almost the same efficiency of execution as the machine level language because this is one-to-one translator between assembly language program and its corresponding machine language program.

The set of symbols and letters forms the assembly language and a translator program (called Assembler) is required to translate the programs written in assembly language into machine language for execution by the computer. It is considered to be a second-generation language

High Level Languages

Assembly language and machine language require extensive knowledge of computer hardware to overcome this limitation, a user writes the instructions in English like sentences to perform the logic of the problem irrespective of the type of computer you are using. The language used for this is referred to as high-level language. High-level languages are simple language that use English and mathematical symbols like +, -, %, /, etc. for its program construction.

Any higher-level language has to be converted to machine language for the computer to understand. Higher-level languages are problem-oriented languages because the instructions are suitable for solving a particular problem. For example COBOL (Common Business Oriented Language) is mostly suitable for business oriented language where there is very little processing and huge output. There are mathematical oriented languages like FORTRAN (Formula Translation) and BASIC (Beginners All-purpose Symbolic Instructions Code) where very large processing is required.

Higher-level languages have a major advantage over machine and assembly languages that higher-level languages are easy to learn and use. It is because that they are similar to the languages used by us in our day-to-day life. The programs can easily be debugged and are machine independent.

Compiler

It is a program that translates the instructions of higher-level languages to machine language. It is called compiler because it compiles every program instruction given in higher-level languages into machine language. Thus compiler is a program translator like assembler but more sophisticated. It scans the entire program first and then translates it into machine code. The program written by the programmer in higher-level language is called source program. After this program is converted to machine language by the compiler it is called object program.

A compiler can translate only those source programs, which have been written, in that language for which the compiler is meant for. For example, FORTRAN compiler will not compile source code written in COBOL language.

The Types of computer

Computers are divided into three types according to their structure, speed and architecture.

1. Analog Computers
2. Digital Computers
3. Hybrid Computers

Analog computers:

"The computers which provide us continuous information are called analog computers."

Analog computers represent physical quantities in the form of waves or in continuous form

Characteristics of the analog computers:

a) These computers have no state
b) The Speed of analog computer is fast
c) These computers are not reliable
d) These computers became the base for digital computers
e) These computers are difficult to operate and use
f) These computers are easy to develop
g) These computers have small memory

Digital Computers:

"The computers which present physical quantities with the help of symbols or numbers and provide us discrete information are called digital computers."

Characteristics of the digital computers:

a) Digital computers have two states On (0) and Off (1).
b) These computers are easy to use.
c) Human being like to use digital computers.
d) These computers are reliable.
e) Digital computers have big memory.
f) Working speed of digital computers is slower as compared to analog computers.

These computers are further divided into different categories such as personal computers, Mainframe computers and super computers.

Hybrid Computers:

"The computers which have qualities of both digital and analog computers are called hybrid computers."

Hybrid computer has the speed of analog and the accuracy of digital computer.

Characteristics of the Hybrid computers:

a) These computers are reliable and provide accurate result.
b) These computers are fast and speedy.

Personal Computers/Desktop computers:

These are small size computers and are used by a single user. Desktop computers are also called Personal computers or PC. We can use these computers easily in offices, colleges, schools, universities, homes, and factories.

Characteristics of Desktop computers:

a) These computers have fast speed and accuracy
b) Small in size
c) Easy to operate
d) These computers are easy to move
e) These computers are cheaper
f) We can use desktop computers as a single user and multi-user environment

Laptop Computers/Notebook:

Lap top computers are another category of personal computers. These computers are small in size and light packed in. These computers are moveable because they work on batteries and can operate without an external power source. Laptop computers are also called Notebook computers because the size of these computers is about one- inch notebook and weight is from four to eight pounds.

Range of Computer Ability

Computers exist in a wide range of sizes and power. The smallest are embedded within the circuitry of appliances, such as televisions and wristwatches. These computers are typically preprogrammed for a specific task, such as tuning to a particular television frequency, delivering doses of medicine, or keeping accurate time. They generally are "hard-wired"—that is, their programs are represented as circuits that cannot be reprogrammed.

Programmable computers vary enormously in their computational power, speed, memory, and physical size. Some small computers can be held in one hand and are called personal digital assistants (PDAs). They are used as notepads, scheduling systems, and address books; if equipped with a cellular phone, they can connect to worldwide computer networks to exchange information regardless of location. Hand-held game devices are also examples of small computers.

Now let us discuss the varieties of computers that we see today. Although they belong to the fifth generation they can be divided into different categories depending upon the size, efficiency, memory and number of users.There are 6 types of computer based on the processing and storing capabilities, they are

Micro Computer: (CSS 1991)

Microcomputer is at the lowest end of the computer range in terms of speed and storage capacity. Its CPU is a microprocessor. The first microcomputers were built of 8-bit microprocessor chips. The most common application of personal computers (PC) is in this category. The PC supports a number of input and output devices. An improvement of 8-bit chip is 16-bit and 32-bit chips. Examples of microcomputer are IBM PC, PC-AT.

Portable Laptop I. Notebook Computers and desktop PCs

Portable laptop and notebook computers and desktop PCs are typically used in businesses and at home to communicate on computer networks. for word processing, to track finances, and for entertainment. They have large amounts of internal memory to store hundreds of programs and documents. They are equipped with a keyboard; a mouse, trackball, or other pointing device; and a video display monitor or liquid crystal display (LCD) to display information. Laptop and notebook computers usually have hardware and software similar to PCs, but they are more compact and have flat, lightweight LCDs instead of television-like video display monitors. Most sources consider the terms "laptop" and "notebook" synonymous.

Workstations

Workstations are similar to personal computers but have greater memory and more extensive mathematical abilities, and they are connected to other workstations or personal computers to exchange data. They are typically found in scientific, industrial, and business environments—especially financial ones, such as stock exchanges—that require complex and fast computations.

Mini Computer:

This is designed to support more than one user at a time. It possesses large storage capacity and operates at a higher speed. The mini computer is used in multi-user system in which various users can work at the same time. This type of computer is generally used for processing large volume of data in an organisation. They are also used as servers in Local Area Networks (LAN).

Mainframes:

These types of computers are generally 32-bit microprocessors. They operate at very high speed, have very large storage capacity and can handle the work load of many users. They are enerally used in centralised databases. They are also used as controlling nodes in Wide Area networks (WAN). Example of mainframes are DEC, ICL and IBM 3000 series.

super Computer:

supercomputers are like mainframe computers that have been designed for optimum processing ower and overall speed. They are the fastest and most expensive machines. They have high ocessing speed compared to other computers. They have also multiprocessing technique. One f the ways in which supercomputers are built is by interconnecting hundreds of microprocessors. Supercomputers are mainly being used for whether forecasting, biomedical esearch, remote sensing, aircraft design and other areas of science and technology. Examples of supercomputers are CRAY YMP, CRAY2, NEC SX-3, CRAY XMP

Embedded Computer:

This Type of Computer is used in a small chip. This means the small chip can be put inside other machines to control the devices. This type of technology is known as embedded computer. For Example - Mobile Phone, Washing Machine, Telephone, Telephone

Difference *between* a Microcomputer and a Minicomputer (CSS 2008)

Microcomputer	Minicomputer
A microcomputer is a standard desktop computer used at a home and in business.	Minicomputers are mid-sized computer used in universities, research labs and small corporations
A microcomputer is a computer with a microprocessor as its CPU.	Minicomputers are faster than microcomputers.
They are cheap, compact and can be easily accommodated on a study table.	They are expensive and larger than microcomputer.
Microcomputer is a single-user computer	Minicomputer is a multi-user computer.
The two most common types of storage devices used with microcomputers are tapes and disks.	For secondary storage, most minicomputers use magnetic disks or tapes.
Microcomputer is not powerful or as fast as minicomputer	Minicomputer is powerful than microcomputer but not as super computer and mainframe computer.
Examples are- Modern computers like desktop, laptop etc	Examples are- IBM 9375, Motorola 68040 etc.

Difference *between* Mainframe Computer *and* Supercomputer (CSS 2008)

Mainframe	Supercomputer
Mainframe uses its processing power to execute multiple programs concurrently.	A Supercomputer utilizes all its processing speed and power in executing a few programs as fast as possible
For Mainframe, performance is measured in terms of MIPS (Millions of Instructions per Second).	The performance of Supercomputer is measured in terms of Flop/s (Floating Point Operations per Second)
Mainframes undertake simple computational task that involves huge amount of external data	Supercomputer executes complicated computations and utilizes large memory.
Mainframes execute broader tasks like critical back end data processing, data warehousing etc.	Supercomputers are purpose built for tasks like simulation, modelling, research etc.

Computer Networks

"... One of the most exciting and important technological fields of our time."

A computer network is a group of interconnected computers. Networks may be classified according to a wide variety of characteristics. This article provides a general overview of some types and categories and presents the basic components of a network.

Based on their scale, networks can be classified as

- Personal Area Network (PAN)
- Local Area Network (LAN)
- Wide Area Network (WAN)

Personal Area Network (PAN)

A personal area network (PAN) is a computer network used for communication among computer devices close to one person. Some examples of devices that are used in a PAN are printers, fax machines, telephones and scanners. The reach of a PAN is typically about 20-30 feet.

Personal area networks may be wired with computer buses such as USB and FireWire. A wireless personal area network (WPAN) can also be made possible with network technologies such as IrDA and Bluetooth

Local Area Network (LAN)

One type of network, a local area network (LAN), consists of several PCs or workstations connected to a special computer called a server, often within the same building or office complex. The server stores and manages programs and data. A server often contains all of a networked group's data and enables LAN workstations or PCs to be set up without large storage capabilities. In this scenario, each PC may have "local" memory (for example, a hard drive) specific to itself, but the bulk of storage resides on the server. This reduces the cost of the workstation or PC because less expensive computers can be purchased, and it simplifies the maintenance of software because the software resides only on the server rather than on each individual workstation or PC. Mainframe computers and supercomputers commonly are networked. They may be connected to PCs, workstations, or terminals that have no computational abilities of their own. These "dumb" terminals are used only to enter data into, or receive output from, the central computer.

Wide area networks (WANs)

Wide area networks (WANs) are networks that span large geographical areas. Computers can connect to these networks to use facilities in another city or country. For example, a person in Quetta can browse through the computerized archives of the Senate in Islamabad. The largest WAN is the Internet, a global consortium of networks linked by common communication programs and protocols (a set of established standards that enable computers to communicate with each other).

Hypertext Transfer Protocol (HTTP) is the main access protocol of the World Wide Web, but it is only one of the hundreds of communication protocols used on the Internet. Web servicesalso use HTTP to allow software systems to communicate in order to share and exchange business logic and data.

The World Wide Web, developed in the 1980s by British physicist Timothy Berners-Lee, is a system of information resources accessed primarily through the Internet. Users can obtain a variety of information in the form of text, graphics, sounds, or video. These data are extensively cross-indexed, enabling users to browse (transfer their attention from one information site to another) via buttons, highlighted text, or sophisticated searching software known as search engines.

Difference *between* LAN *and* WAN

	LAN	WAN
Definition	LAN is a computer network that connects computers in small areas	WAN is a network that covers a broad area using private or public network transports
Data transfer rates	LAN offers high data transfer rates	WAN has lower data transfer rates due to congestion
Speed	80-90 mbps	10-20 mbps
Technology	LANs use technologies such as Ethernet and Token Ring to connect to other networks	WAN uses technologies such as MPLS, ATM, Frame Relay and X.25 for data connection over greater distances
Bandwidth	High bandwidth is available for transmission	Low bandwidth available for transmission.
Connection	One LAN can be connected to other LANs over any distance via telephone lines and radio waves.	Computers connected to a wide-area network are often connected through public networks, such as the telephone system. They can also be connected through leased lines or satellites.
Components	Layer 2 devices like switches, bridges. Layer 1 devices like hubs, repeaters.	Layers 3 devices Routers, Multi-layer Switches and Technology specific devices like ATM or Frame-relay Switches etc
Problems	LANs tend to have fewer problems associated with them	WANs have more problems due to the large amount of system and data that is present.
Data Transmission Error	Experiences fewer data transmission errors.	Experiences more data transmission errors.
Cost	Set-up costs are low as the devices required to set up the networks are cheap.	Set-up costs are high, especially in remote locations where set-up is not done. However, WANs using public networks are cheap.
Ownership	LAN networks can be owned up private companies or people that set it up at homes	WAN are not owned up any one organization but exist under collective or distributed ownership
Spread	The network is spread to a very small location	The network can be spread world-wide.
Maintenance costs	Maintenance costs are low as the area coverage is small.	Maintenance costs are high as the area coverage is world-wide.
Congestion	Less congestion	More congestion

Computer Virus

(CSS 2008)

A computer virus, according to Webster's Collegiate Dictionary, is "a computer program usually hidden within another seemingly innocuous program that produces copies of itself and inserts them into other programs or files, and that usually performs a malicious action (such as destroying data)". Two categories of viruses, macro viruses and worms, are especially common today. Computer viruses are never naturally occurring; they are always man-made. Once created and released, however, their spread is not directly under human control.

There are different types of viruses which can be classified according to their origin

Memory Resident Virus

These viruses fix themselves in the computer memory and get activated whenever the OS runs and infects all the files that are then opened.

Direct Action Viruses

The main purpose of this virus is to replicate and take action when it is executed. When a specific condition is met, the virus will go into action and infect files in the directory or folder that are specified in the AUTOEXEC.BAT file path. This batch file is always located in the root directory of the hard disk and carries out certain operations when the computer is booted.

Overwrite Viruses

A virus of this kind is characterized by the fact that it deletes the information contained in the files that it infects, rendering them partially or totally useless once they have been infected.

Boot Sector Virus

This type of virus affects the boot sector of a hard disk. This is a crucial part of the disk, in which information of the disk itself is stored along with a program that makes it possible to boot (start) the computer from the disk. This type of virus is also called Master Boot Sector Virus or Master Boot Record Virus.

Macro Virus

Macro viruses infect files that are created using certain applications or programs that contain macros, like .doc, .xls, .pps, .mdb, etc. These mini-programs make it possible to automate series of operations so that they are performed as a single action, thereby saving the user from having to carry them out one by one. These viruses automatically infect the file that contains macros, and also infects the templates and documents that the file contains. It is referred to as a type of e-mail virus.

Directory Virus

Directory viruses (also called Cluster Virus/File System Virus) infect the directory of your computer by changing the path that indicates the location of a file. When you execute a program file with an extension .EXE or .COM that has been infected by a virus, you are unknowingly running the virus program, while the original file and program is previously moved by the virus. Once infected, it becomes impossible to locate the original files.

Polymorphic Virus

Polymorphic viruses encrypt or encode themselves in a different way (using different algorithms and encryption keys) every time they infect a system. This makes it impossible for antivirus software to find them using string or signature searches (because they are different in each encryption). The virus then goes on to create a large number of copies.

Companion Viruses

Companion viruses can be considered as a type of file infector virus, like resident or

direct action types. They are known as companion viruses because once they get into the system they 'accompany' the other files that already exist. In other words, to carry out their infection routines, companion viruses can wait in memory until a program is run (resident virus), or act immediately by making copies of themselves (direct action virus).

FAT Virus

The file allocation table (FAT) is the part of a disk used to store all the information about the location of files, available space, unusable space, etc.

Multipartite Virus

These viruses spread in multiple ways possible. It may vary in its action depending upon the operating system installed and the presence of certain files.

Web Scripting Virus

Many web pages include complex codes in order to create an interesting and interactive content. This code is often exploited to bring about certain undesirable actions.

Worms

A worm is a program very similar to a virus; it has the ability to self-replicate and can lead to negative effects on your system. But they can be detected and eliminated by an antivirus software.

Trojans

Another unsavory breed of malicious code are Trojans or Trojan horses, which unlike viruses, do not reproduce by infecting other files, nor do they self-replicate like worms. In fact, it is a program which disguises itself as a useful program or application.

Ways to Catch a Computer Virus

There are several ways to catch a computer virus:

From **the Internet** - viruses can be attached to various types of Internet files, such as graphics and program files that people download from the Internet. Just browsing the Internet does not put your computer at risk. You have to download and install a file for a virus to be able to infect a computer.

From **E-Mail** - viruses often travel via e-mail attachments. E-mail messages by themselves do not carry viruses. Only .exe, .com or other types of executable files can carry a virus.

From a **Computer Network** - Computer Networks are groups of computers linked together by a large computer called a server. The server and these computers constantly share information. If one file that is used by several network users becomes infected with a virus, the virus will quickly spread to the other users.

Symptoms of a Computer Virus

The following are some possible indications that a computer has been infected by a virus. These problems can also be caused by non-virus problems, but they are the most reported symptoms of a computer virus infection.

1. Computer programs take longer to load than normal.
2. The computer's hard drive constantly runs out of free space.
3. The floppy disk drive or hard drive runs when you are not using it.
4. New files keep appearing on the system and you don't know where they came from.
5. Strange sounds or beeping noises come from the computer or keyboard.
6. Strange graphics are displayed on your computer monitor.
7. Files have strange names you don't recognize.
8. You are unable to access the hard drive when booting from the floppy drive.

9. Program sizes keep changing.
10. Conventional memory is less than it used to be and you can't explain it.
11. Programs act erratically.

Safe Computing Tips

1. Load only software from original disks or CD's. Pirated or copied software is always a risk for a virus.
2. Execute only programs of which you are familiar as to their origin. Programs sent by email should always be suspicious.
3. Computer uploads and "system configuration" changes should always be performed by the person who is responsible for the computer.
4. Password protection should be employed.
5. Check all shareware and free programs downloaded from on-line services with a virus checking program.
6. Purchase or download a anti-virus program that runs as you boot or work your computer. Up-date it frequently. There are free anti-virus programs availible.

Telecommunication

What is telecommunication?

Telecommunication: Any transmission, emission or reception of signs, signals, writing, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems.

Constitution and Convention of the International Telecommunication Union, Optional Protocol and Recommendations, Geneva 1992

Telecommunications, devices and systems that transmit electronic signals across long distances. Telecommunications enables people around the world to contact one another, to access information instantly, and to communicate from remote areas. Telecommunications usually involves a sender of information and one or more recipients linked by a technology, such as a telephone system, that transmits information from one place to another. Telecommunications devices convert different types of information, such as sound and video, into electronic signals. The signals can then be transmitted by means of media such as telephone wires or radio waves. When a signal reaches its destination, the device on the receiving end converts the electronic signal back into an understandable message, such as sound over a telephone, moving images on a television, or words and pictures on a computer screen. Telecommunications enables people to send and receive personal messages across town, between countries, and to and from outer space. It also provides the key medium for news, data, information, and entertainment.

Telecommunications messages can be sent in a variety of ways and by a wide range of devices. The messages can be sent from one sender to a single receiver (point-to-point) or from one sender to many receivers (point-to-multipoint). Personal communications, such as a telephone conversation between two people or a facsimile (fax) message, usually involve point-to-point transmission. Point-to-multipoint telecommunications, often called broadcasts, provide the basis for commercial radio and television programming.

How Telecommunications Works

Telecommunications begin with messages that are converted into electronic signals. The signals are then sent over a medium to a receiver, where they are decoded back into a form that the person receiving the message can understand. There are a variety of ways to create and decode signals, and many different ways to transmit signals.

Wireless Telecommunications

Wireless is a term used to describe telecommunications in which electromagnetic waves rather than some form of wire) carry the signal over part or all of the communication path. Some monitoring devices, such as intrusion alarms, employ acoustic waves at frequencies above the range of human hearing; these are also sometimes classified as wireless.

The first wireless transmitters went on the air in the early 20th century using radiotelegraphy (Morse code). Later, as modulation made it possible to transmit voices and music via wireless, the medium came to be called "radio." With the advent of television, fax, data communication, and the effective use of a larger portion of the spectrum, the term "wireless" has been resurrected.

Common examples of wireless equipment in use today include:

- **Cellular phones and pagers** -- provide connectivity for portable and mobile applications, both personal and business
- **Global Positioning System (GPS)** -- allows drivers of cars and trucks, captains of boats and ships, and pilots of aircraft to ascertain their location anywhere on earth
- **Cordless computer peripherals** -- the cordless mouse is a common example; keyboards and printers can also be linked to a computer via wireless
- **Cordless telephone sets** -- these are limited-range devices, not to be confused with cell phones
- **Home-entertainment-system control boxes** -- the VCR control and the TV channel control are the most common examples; some hi-fi sound systems and FM broadcast receivers also use this technology
- **Remote garage-door openers** -- one of the oldest wireless devices in common use by consumers; usually operates at radio frequencies
- **Two-way radios** -- this includes Amateur and Citizens Radio Service, as well as business, marine, and military communications
- **Baby monitors** -- these devices are simplified radio transmitter/receiver units with limited range
- **Satellite television** -- allows viewers in almost any location to select from hundreds of channels
- **Wireless LANs or local area networks** -- provide flexibility and reliability for business computer users

Wireless technology is rapidly evolving, and is playing an increasing role in the lives of people throughout the world. In addition, ever-larger numbers of people are relying on the technology directly or indirectly. (It has been suggested that wireless is overused in some situations, creating a social nuisance.) More specialized and exotic examples of wireless communications and control include:

- **Global System for Mobile Communication (GSM)** -- a digital mobile telephone system used in Europe and other parts of the world; the de facto wireless telephone standard in Europe
- **General Packet Radio Service (GPRS)** -- a packet-based wireless communication service that provides continuous connection to the Internet for mobile phone and computer users
- **Enhanced Data GSM Environment (EDGE)** -- a faster version of the Global System for Mobile (GSM) wireless service

- **Universal Mobile Telecommunications System (UMTS)** – a broadband, packet-based system offering a consistent set of services to mobile computer and phone users no matter where they are located in the world
- **Wireless Application Protocol (WAP)** – a set of communication protocols to standardize the way that wireless devices, such as cellular telephones and radio transceivers, can be used for Internet access
- **i-Mode** – the world's first "smart phone" for Web browsing, first introduced in Japan, provides color and video over telephone sets

Wireless can be divided into:

- **Fixed wireless** – the operation of wireless devices or systems in homes and offices, and in particular, equipment connected to the Internet via specialized modems
- **Mobile wireless** – the use of wireless devices or systems aboard motorized, moving vehicles; examples include the automotive cell phone and PCS (personal communications services)
- **Portable wireless** – the operation of autonomous, battery-powered wireless devices or systems outside the office, home, or vehicle; examples include handheld cell phones and PCS units
- **IR wireless** – the use of devices that convey data via IR (infrared) radiation; employed in certain limited-range communications and control systems

Global Positioning System (GPS)

PS – An Overview

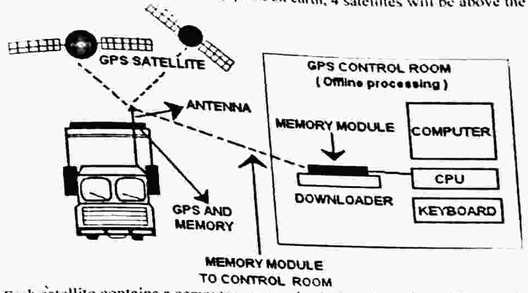
The GPS (*Global Positioning System*) is a "constellation" of 24 well-spaced satellites that d the earth and make it possible for people with ground receivers to pinpoint their geographic ation. The location accuracy is anywhere from 100 to 10 ers for most equipment. Accuracy can be pinpointed to han 1 meter with special military-approved equipment PS equipment is widely used in science and has now ome sufficiently low-cost so that almost anyone can own a PS receiver.

e GPS has three components namely:

1) The space segment: consisting of 24 satellites orbiting the earth at an altitude of 11000 nautical miles.
2) The user segment: consisting of a receiver, which is mounted on the unit whose location has to be determined.
3) The control segment: consists of various ground stations controlling the satellites.

The GPS is owned and operated by the U.S Department of Defense but is available for eral use around the world. Briefly, here's how it works:

1) 21 GPS satellites and 3 spare satellites are in orbit at 10,600 miles above the earth. The satellites are spaced so that from any point on earth, 4 satellites will be above the horizon.



2) Each satellite contains a computer, an atomic clock and a radio. With an understanding of its own orbit and the clock, it continually broadcasts its changing position and time. (Once a day, each satellite checks its own sense of time and position with a ground station and makes any minor correction).
3) On the ground, any GPS receiver contains a computer that "triangulates" its own position by getting bearings from 3 or 4 satellites. The result is provided in the form of a geographic position- Longitude and latitude, for most of the receivers, within 100 meters.

4) If the receiver is also equipped with a display screen that shows a map, the position can be shown on the map.
5) If the 4th satellite can be received, the receiver/computer can figure out the altitude as well as the geographic position.
6) If you are moving, your receiver may also be able to calculate your speed and direction of travel and give the estimated times of arrival to specified destinations.

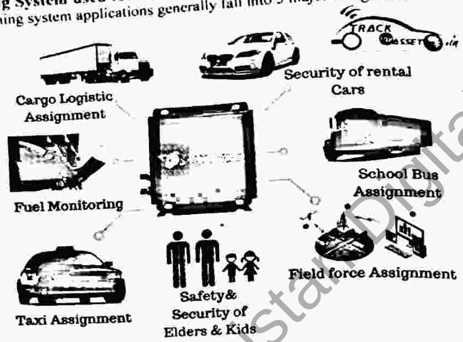
The GPS is being used in science to provide data that has never been available before in the quantity and degree of accuracy that the GPS makes possible. Scientists are using the GPS to measure the movement of the arctic ice sheets, the Earth's tectonic plates, and volcanic activity. GPS technologies. GPS systems are extremely versatile and can be found in almost any industry sector.

They can be used to map forests, help farmers harvest their fields and navigate aeroplanes on the ground or in the air.

GPS systems are used in military applications and by emergency crews to locate people in need of assistance.GPS technologies are often working in many areas that we do not normally consider.

GPS Tracking System used for which Industry?

Global positioning system applications generally fall into 5 major categories:



1. Location – determining a position
2. Navigation – getting from one location to another
3. Tracking – monitoring object or personal movement
4. Mapping – creating maps of the world
5. Timing – bringing precise timing to the world

Some of the applications that GPS systems are currently being used for around the world

- Mining Industry
- Manufacturing

- Construction Companies
- Dairy Industry
- Parcel Services
- Cab Industry
- Fishing Industry
- Coal Transportation
- FMCG industry
- Cold chain Transportation
- Pharmaceutical Industry
- Chemical
- Airport Management
- Hospitality Industry

These days doctors, scientists, farmers, soldiers, pilots, hikers, delivery drivers, sailors, fishermen, dispatchers, athletes, and people from many other walks of life are using GPS systems in ways that make their work more productive, safer and easier.

Social Networking

If we take the words "social media" at their basic level, it is media that allows people to connect with each other. Email allows you to connect and interact with other people, so it is "social". But given most email is just text based messaging and delivered and received on a one-to-one basis, it's a communication tool rather than media.

The Oxford Living Dictionaries website defines it as "Websites and applications to create and share content or to participate in social networking". Facebook, LinkedIn and Twitter fit neatly within this definition.

All of these sites allow users to create and share content with *an audience* – the essential media element that email is missing. On all sites, there are methods of connection and building a network: Facebook friends, followers on Twitter and connections on LinkedIn. In many cases, you will not have met all of these connections in real life (although that is less true in the case of Facebook friends), so followers can often represent more of an "audience" than being actual collaborators.

Social media is also closely associated with "Web 2.0" – the concept of the "second stage" of the web popularised by Tim O'Reilly and Dale Dougherty. In the first stage of the web, users were limited to passive viewing of content; for example, they would go to a website and be able to access its information, but not be able to interact with it.

With Web 2.0, the Internet is thought of as a platform in itself, where people are essentially building applications within it. The more people collaborating, the better the applications get, and where users are able to interact with the content and create their own.

Where did social media come from?

While interactive chat rooms stretch back to before the World Wide Web, social networking as we understand it today really began to evolve in the late 1990s with the launch of multiple instant messaging services. For instance, both MSN Messenger and Yahoo! Messenger, along with their Internet chat rooms, both launched in 1999.

Instant messaging isn't comfortably defined as social media, because, similar to email, it's mostly text based and is more of a one-to-one communication tool, although you could participate in small groups. However, messaging is a crucial element of many social networking services today and an important precursor.

The real "Web 2.0" social media, where users could upload and share content, along with networking with other people, began a few years later.

How did social media grow so quickly?

It was really advances in web publishing technology and the idea of inverting access to publishing tools from backend Content Management Systems (CMS) to front-end users that first enabled social media. But there are four other crucial points in its history that led to it becoming ubiquitous.

1. Broadband

Do you remember trying to look at images on a web browser using a 56 k/b dial up connection? In the 1990s, this activity was painfully slow – often prohibitively, and not helped by a lot of the web not adhering to usability standards that we see as the norm today.

Download a low quality film of around 700 MB would take 3-5 days. The creation of broadband infrastructure that began in the early 2000s was the first important step in allowing social media. Faster download and upload times meant that people could download and upload from the new social media tools much more quickly.

2. Cloud computing

In his book *Thank You for Being Late: An Optimist's Guide to Thriving in the Age of Accelerations*, Thomas L. Friedman says 2007 as being one of the seminal years in Internet technology. The Kindle was launched, Google introduced Android, Steve Jobs unveiled the first iPhone, and AirBnb was conceived to name a few.

Perhaps most importantly was the launch of Hadoop, which enabled the mass storage and analysis of unstructured data. This led to cloud computing, which is one of the key reasons why social networks can store such vast quantities of data.

3. Mobile Internet

The smartphone became a widely owned product around 2009-2010. Previously, people could only access social media from desktops, which limited their time spent and possible interactions.

With the advent of fully functioning web mobile web browsers, native social media applications, and WiFi and mobile data networks, it was possible to be on social media at almost any time if you wanted to be.

4: In-built 'virality'

A classic story of the early Internet is how the creators of Hotmail were told by an investor to automatically sign off every email with "Get your free email at HoTMaiL" and a link back to their homepage. As people received Hotmail emails, they were tempted to sign up to the service because of the message, and the popularity of the service exploded.

One of YouTube's great viral marketing ploys was to allow anyone to embed the videos on their own website. YouTube embeds soon became a feature of many articles.

Both of these are examples of in-built "virality" - the content within the services may be viral (like chain emails or viral videos being passed on *by email*) but also the way the networks themselves expanded was viral.

Services like Twitter and Facebook asked new sign ups to email friends on their email lists to get them to join, suggesting the experience will be better if you do. Once signed up, users tend to receive a lot of email notifications from the platforms about almost every interaction (unless you turn them off). The networks are then gamified through the enticement to gain likes, retweets or followers. This keeps people going back and sticking to the network.

With more than 47.5 million mobile internet users and another 2 million fixed broadband subscribers in the country, Pakistan has conveniently surpassed South Korea, Spain, Canada, Australia and countless other developed countries to rank 20th in the world for online population.

Information System

Information system, an integrated set of components for collecting, storing, and processing data and for delivering information, knowledge, and digital products. Business firms and other organizations rely on information systems to carry out and manage their operations, interact with their customers and suppliers, and compete in the marketplace.

Components of information systems

An information system is essentially made up of five components hardware, software, database, network and people. These five components integrate to perform input, process, output, feedback and control.

Hardware consists of input/output device, processor, operating system and media devices. Software consists of various programs and procedures. Database consists of data organized in the required structure. Network consists of hubs, communication media and network devices. People consist of device operators, network administrators and system specialist.

Information processing consists of input; data process, data storage, output and control. During input stage data instructions are fed to the systems which during process stage are worked upon by software programs and other queries. During output stage, data is presented in structured format and reports.

Classification of Information System

In any given organization information system can be classified based on the usage of the information. Therefore, an information system in an organization can be divided into operations support system and management support system.

- **Operations support system**
- In an organization, data input is done by the end user which is processed to generate information products i.e. reports, which are utilized by internal and or external users. Such a system is called operation support system.
- The purpose of the operation support system is to facilitate business transaction, control production, support internal as well as external communication and update organization central database. The operation support system is further divided into a transaction-processing system, processing control system and enterprise collaboration system.
- **Transaction Processing System (TPS)**
- In manufacturing organization, there are several types of transaction across department. Typical organizational departments are Sales, Account, Finance, Plant, Engineering, Human Resource and Marketing. Across which following transaction may occur sales order, sales return, cash receipts, credit sales; credit slips, material accounting, inventory management, depreciation accounting, etc.
- These transactions can be categorized into batch transaction processing, single transaction processing and real time transaction processing.
- **Process Control System**
- In a manufacturing organization, certain decisions are made by a computer system without any manual intervention. In this type of system, critical information is fed to the system on a real-time basis thereby enabling process control. This kind of systems is

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referred as process control systems.

- **Enterprise Collaboration System**
- In recent times, there is more stress on team effort or collaboration across different functional teams. A system which enables collaborative effort by improving communication and sharing of data is referred to as an enterprise collaboration system.
- **Management Support System**
- Managers require precise information in a specific format to undertake an organizational decision. A system which facilitates an efficient decision making process for managers is called management support system.

Management support systems are essentially categorized as management information system, decision support system, expert system and accounting information system.

Management information system provides information to manager facilitating the routine decision-making process. Decision support system provides information to manager facilitating specific issue related solution.

Fibre Optics

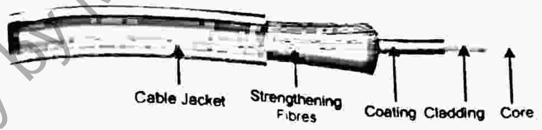
It is a communication technology that makes use of light to carry data and information long a glass fibre as thin as a human hair.

How does it work?

The part that carries the light from one place to another is called a fibre-optic cable. metimes called a 'light-pipe'. This describes its function very well as a fibre optic cable is esigned to allow light to pass through it with very little loss.

Q: How an Optical Fiber' is constructed (CSS-2018)

Fibre optic cable construction



Core

This is the physical medium that transports optical data signals from an attached light source to a receiving device. The core is a single continuous strand of glass or plastic that's measured in microns (µ) by the size of its outer diameter. The larger the core, the more light the cable can carry.

All fibre optic cable is sized according to its core's outer diameter. The three multimode sizes most commonly available are 50, 62.5, and 100 microns. Single-mode cores are generally less than 9 microns.

Cladding

This is the thin layer that surrounds the fibre core and serves as a boundary that contains the light waves and causes the refraction, enabling data to travel throughout the length of the fibre segment.

Coating

This is a layer of plastic that surrounds the core and cladding to reinforce and protect the fibre core. Coatings are measured in microns and can range from 250 to 900 microns.

Strengthening fibres

These components help protect the core against crushing forces and excessive tension during installation. The materials can range from Kevlar® to wire strands to gel-filled sleeves.

Cable jacket

This is the outer layer of any cable. Most fibre optic cables have an orange jacket, although some types can have black or yellow jackets.

Is it just any light?

No, fibre optic is transparent at a very precise wavelength of light i.e. colour. Typically it is very transparent at 1550 nm (nano metre is 1 thousand millionth of a metre). We would see it is a reddish colour.

How is the light created in the first place?

There are two main ways.

1. A Light Emitting Diode (LED).

LEDs are very cheap and do produce reasonably pure light of the right wavelength. So they are used for low power, short distance applications such as local area networks. LEDs are good for a few kilometers and a speed of about 100Mb/sec

Only about a hundredth (1%) of the light it produces is useful for the cable. But even that is good enough for smallish distances.

2. Laser Beam

This is more expensive but has a far higher purity than LED. This means that nearly half the light is useful in the cable, so it is very efficient.

Power can be also be much higher, so allowing far greater distances to be covered.

How fast can it transmit data?

Transmission speeds can be extremely high.

For example, recently a 160Km length of cable carried information at 14,000 Gigabits / sec. This kind of performance is used in oceanic cables that connect continents together.

How does it compare to good old copper?

It is very tough - it does not corrode, unlike copper and it is not affected by electrical interference such as lightning or stray radio signals. But it is more expensive, so copper is still used for most local communications.

Advantages of Fiber Optic Systems

"Fiber optic transmission systems – a fiber optic transmitter and receiver, connected by fiber optic cable – offer a wide range of benefits not offered by traditional copper wire or coaxial cable. These include:

1. The ability to carry much more information and deliver it with greater fidelity than either copper wire or coaxial cable.
2. Fiber optic cable can support much higher data rates, and at greater distances, than coaxial cable, making it ideal for transmission of serial digital data.
3. The fiber is totally immune to virtually all kinds of interference, including lightning, and will not conduct electricity. It can therefore come in direct contact with high voltage electrical equipment and power lines. It will also not create ground loops of any kind.
4. As the basic fiber is made of glass, it will not corrode and is unaffected by most chemicals. It can be buried directly in most kinds of soil or exposed to most corrosive atmospheres in chemical plants without significant concern.
5. Since the only carrier in the fiber is light, there is no possibility of a spark from a broken fiber. Even in the most explosive of atmospheres, there is no fire hazard, and no danger of electrical shock to personnel repairing broken fibers.
6. Fiber optic cables are virtually unaffected by outdoor atmospheric conditions, allowing them to be lashed directly to telephone poles or existing electrical cables without concern for extraneous signal pickup.
7. A fiber optic cable, even one that contains many fibers, is usually much smaller and lighter in weight than a wire or coaxial cable with similar information carrying capacity. It is easier to handle and install, and uses less duct space. (It can frequently be installed without ducts.)
8. Fiber optic cable is ideal for secure communications systems because it is very difficult to tap but very easy to monitor. In addition, **there is absolutely no electrical radiation from a fiber."**

Who invented fiber optics?

- 1840s: Swiss physicist **Daniel Colladon** (1802–1893) discovered he could shine light along a water pipe. The water carried the light by internal reflection.
- 1870: An Irish physicist called **John Tyndall** (1820–1893) demonstrated internal reflection at London's Royal Society. He shone light into a jug of water. When he poured some of the water out from the jug, the light curved round following the water's path. This idea of "bending light" is exactly what happens in fiber optics. Although Colladon is the true grandfather of fiber-optics, Tyndall often earns the credit.
- 1930s: **Heinrich Lamm** and **Walter Gerlach**, two German students, tried to use light pipes to make a gastroscope—an instrument for looking inside someone's stomach.
- 1950s: In London, England, Indian physicist **Narinder Kapany** (1927–) and British physicist **Harold Hopkins** (1918–1994) managed to send a simple picture down a light pipe made from thousands of glass fibers. After publishing many scientific papers, Kapany earned a reputation as the "father of fiber optics."
- 1957: Three American scientists at the University of Michigan, **Lawrence Curtiss**, **Basil Hirschowitz**, and Wilbur Peters, successfully used fiber-optic technology to make the world's first gastroscope.
- 1960s: Chinese-born US physicist **Charles Kao** (1933–) and his colleague George Hockham realized that impure glass was no use for long-range fiber optics. Kao suggested that a fiber-optic cable made from very pure glass would be able to carry telephone signals over much longer distances and was awarded the 2009 Nobel Prize in Physics for this ground-breaking discovery.
- 1960s: Researchers at the **Corning Glass Company** made the first fiber-optic cable capable of carrying telephone signals.
- ~1970: Donald Keck and colleagues at Corning found ways to send signals much further (with less loss) prompting the development of the first low-loss optical fibers.
- 1977: The first fiber-optic telephone cable was laid between Long Beach and Artesia, California.
- 1997: A huge transatlantic fiber-optic telephone cable called FLAG (Fiber-optic Link Around the Globe) was laid between London, England and Tokyo, Japan.

Cell phone

Alternatively referred to as a **cell**, **cellular**, and **cellular phone**, a **cell phone** is a **mobile** or **portable phone**. It enables a user to communicate almost anywhere in the world. The cell phone was invented by Dr. Martin Cooper, along with his team of developers at Motorola. The first cell phone weighed 2.4 pounds and was 9 inches long. Dr. Cooper also made the first cell phone call at Motorola on April 3, 1973.

New cell phones are much lighter than the old brick cell phones, much smaller, and have LCD (often a color LCD) to display contacts, pictures, ringtones, apps, games, etc.

Cell phone capabilities

Today, many cell phones are called smartphones and are capable of doing almost anything a computer is capable of doing. Below, are just a few examples of what some of the new phones are capable of doing.

- Take and make calls to any other person with a phone
- Send and receive text messages
- Take, view, and store pictures and videos using a built-in camera

- Access the Internet, e-mail, chat, and even download apps for the phone
- Play games and have access to common programs, such as a calculator, contacts, calendar, clock, to-do list, etc.
- Remotely control other devices connected to the Internet or connected via Bluetooth
- Store and run files
- Play music and watch movies

How cellphone calls travel

When you speak into a cellphone, a tiny microphone in the handset converts the up-and-down sounds of your voice into a corresponding up-and-down pattern of electrical signals. A microchip inside the phone turns these signals into strings of numbers. The numbers are packed up into a radio wave and beamed out from the phone's antenna (in some countries, the antenna is called an aerial). The radio wave races through the air at the speed of light until it reaches the nearest cellphone mast.

The mast receives the signals and passes them on to its base station, which effectively coordinates what happens inside each local part of the cellphone network, which is called a cell. From the base station, the calls are routed onward to their destination. Calls made from a cellphone to another cellphone on the same network travel to their destination by being routed to the base station nearest to the destination phone, and finally to that phone itself. Calls made to a cellphone on a different network or a land line follow a more lengthy path. They may have to be routed into the main telephone network before they can reach their ultimate destination.

Satellite

A satellite is a moon, planet or machine that orbits a planet or star. For example, Earth is a satellite because it orbits the sun. Likewise, the moon is a satellite because it orbits Earth. Usually, the word "satellite" refers to a machine that is launched into space and moves around Earth or another body in space.

Earth and the moon are examples of natural satellites. Thousands of artificial, or man-made, satellites orbit Earth. Some take pictures of the planet that help meteorologists predict weather and track hurricanes. Some take pictures of other planets, the sun, black holes, dark matter or faraway galaxies. These pictures help scientists better understand the solar system and universe.

What Was the First Satellite in Space?

Sputnik 1 was the first satellite in space. The Soviet Union launched it in 1957.

Still other satellites are used mainly for communications, such as beaming TV signals and phone calls around the world. A group of more than 20 satellites make up the Global Positioning System, or GPS.

There are dozens upon dozens of natural satellites in the solar system, with almost every planet having at least one moon. Saturn, for example, has at least 53 natural satellites, and between 2004 and 2017, it also had an artificial one — the Cassini spacecraft, which explored the ringed planet and its moons.

Artificial satellites, however, did not become a reality until the mid-20th century. The first artificial satellite was Sputnik, a Russian beach-ball-size space obe that lifted off on Oct. 4, 957. That act shocked much f the western world, as it was elieved the Soviets did not ave the capability to send atellites into space.

Moons around other worlds

Most planets in our solar system have natural satellites, which we also call moons. For the inner planets: Mercury and Venus each have no moons. Earth has one relatively large moon, while Mars has two asteroid-sized small moons called Phobos and Deimos. (Phobos is slowly spiralling into Mars and will likely break apart or fall into the surface in a few thousand years.) Beyond the asteroid belt, are four gas giant planets that each have a pantheon of moons? As of late 2017, Jupiter has 69 known moons, Saturn has 53, Uranus has 27 and Neptune has 13 or 14. New moons are occasionally discovered – mainly by missions (either past or present, as we can analyze old pictures) or by performing fresh observations by telescope.

Types of Satellite

Satellites can be classified by their function since they are launched into space to do a specific ob. The type of satellite that is launched to monitor cloud patterns for a weather station will be different than a satellite launched to send television signals across Canada. The satellite must be designed specifically to fulfill its role.

Below are the names of nine different types of satellites.

1. Astronomical Satellites

Astronomical satellites are satellites used for the observation of distant planets and galaxies including other outer space objects. Astronomical satellites are also known as space telescopes or space observatory. The first two operational astronomical satellites were the American Orbiting Astronomical Observatory OAO-2 and the Soviet Union's Orion 1 ultraviolet telescope launched in 1968 and 1971 respectively.

2. Biosatellites

Biosatellites are satellites primarily designed to carry life into space. The first three Biosatellites were launched by NASA between 1966 and 1969 and carried fruit flies, wheat seedlings, frog eggs, bacteria and a monkey. On November 3, 1957 Sputnik 2 became the first satellite to carry an animal in space, a dog named Laika.

3. Communication Satellites

Communication satellites are human-made satellites that transmit and amplify radio telecommunications signals through transponders. A communication satellite acts as a communication channel between the transmitter and the receiver based on different locations on Earth. Such satellites are used for radio, television, military, internet, and telephone applications. The Earth's orbit has about 2,000 communication satellites that are used by government and private organizations. The first artificial communication satellite was launched on October 4, 1957. It was known as Sputnik 1 and operated by the Soviet Union.

4. Earth Observation Satellites

Earth observation satellites are satellites primarily designed to observe planet Earth from orbit. Earth observation satellites are similar to reconnaissance satellites. However, they are not intended for military purposes but map making, meteorology, and environmental monitoring. A good number of earth observation satellites contain devices that should be controlled in relatively low altitudes. Examples of earth observation satellites include; DubaiSat-1, MetOp, UEMETSAT, ERS-1, E visit among others.

5. Navigational Satellite

Navigational satellites are primarily designed to help vessels, aircraft, and vehicle operators determine their geographical location. Originally navigational satellites were created so that nuclear submarines could successfully navigate waters during inertia. Navigation satellites allow small electronic receivers to determine elevation, latitude, altitude, and longitudinal locations to high accuracy. The first navigation satellite was declared operational in 1962 after

Transit 5A was launched. Due to certain inherent limitations, there was a sudden instigation in the development of more advanced navigational satellites.

6. Killer Satellites

Killer satellites are satellites primarily designed to destroy warheads from enemy countries, satellites and other outer space objects that pose a danger to life on earth. The first killer satellite was declared operational in 1973 following a series of failed attempts.

7. Crewed Spacecraft (spaceships)

A crewed spacecraft, also known as manned spaceflight or human spaceflight, is a satellite with human passengers on board. Crewed spacecraft are either operated remotely from ground stations located on Earth or directly by the human crew. On April 21, 1961 the Vostok manned by cosmonaut Yuri Gagarin became first manned spaceflight to orbit the earth. The International Space Station is a manned spacecraft has continuously been present in space for 16 years.

8. Miniaturized Satellites

Miniaturized satellites are small satellites usually of low mass and a weight lighter than 1100 lb. Miniature satellites are also known as "smallsats" or "small satellites". The primary objective of creating miniature satellites is to reduce the costs, as bigger satellites require huge rockets with greater thrust and are expensive to maintain. Tiny satellites are lighter because of their size, and several of them can be launched.

9. Reconnaissance Satellites

Reconnaissance satellites are satellites designed to observe the Earth for military purposes. Such satellites comprise of infrared sensors that trace missiles launched and electronic sensors that eavesdrop on confidential conversations amongst other acts of military surveillance. Most of the information on reconnaissance satellites is classified since it is a military operative. A reconnaissance satellite might also be referred to as spy satellite.

10. Recovery Satellites

Recovery satellites are also known as space capsules. They provide the recovery of biological, reconnaissance, space production and other consignments from space and the Earth's orbit. Most recovery satellites are manned as they are fully operational. This includes Mercury and Vostok and later Soyuz, Shenzhou, L3, Gemini, TKS, Apollo Command Module among others. A recovery satellite is required to have all the things necessary for everyday life including water, food, and air and must protect the astronauts from radiation and frigid space weather.

11. Space Stations

A space station is a rocket ship designed to support crew members. It hovers in space over a long period in order for other spacecraft to Harbor. A space station is differentiated from other spacecraft with passengers aboard by the lack of superior landing systems and spacecraft propulsion. The earth's orbit has three space stations as of September 2016 namely: China's Tiangong-2, Tiangong-1, and the International Space Station.

12. Tether Satellites

Tether satellites are satellites that are connected by a thin cable known as a tether to another satellite. Tether satellites are mainly used for altitude control, stabilization, propulsion, maintaining relative positions of a larger spacecraft sensor system, and momentum exchange. There are different types of tether satellites including skyhooks, format flying tethers, Momentum exchange tethers, and electrodynamic tethers. Satellite tethers tend to be relatively cheaper than spacecraft using rocket engines depending on the objective of the mission and altitude.

13. Weather Satellites

Weather satellites, also known as meteorological satellites, are predominantly used to onitor and record the Earth's climate and weather. The satellites are a consistent source of up-date information about atmospheric conditions. Weather satellites are capable of seeing more an just that cloud systems including sand and dust storms, auroras, city lights, snow cover, ergy flows, fires, ice mapping, effects of pollution, and ocean currents among others. eteorological satellites also help monitor volcanic activity on specific mountains and can detect anges in the earth's ice field, sea state, vegetation and ocean color. The first successful weather tellite Tiros 1 was launched on April 1st, 1960 by NASA. The satellite broadcasted infrared levision pictures of the earth's cloud cover and even detected the development of hurricanes and eteorologists were able to chart their paths.

Artificial Intelligence (AI)

What is artificial intelligence (AI)? (CSS-2016)

Back in the 1950s, the fathers of the field Minsky and McCarthy, described artificial ntelligence as any task performed by a program or a machine that, if a human carried out the ame activity, we would say the human had to apply intelligence to accomplish the task.

According to the father of Artificial Intelligence, John McCarthy, it is *"The science and engineering of making intelligent machines, especially intelligent computer programs"*.

Artificial Intelligence is a way of **making a computer, a computer-controlled robot, or a software think intelligently**, in the similar manner the intelligent humans think.

AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.

Philosophy of AI

While exploiting the power of the computer systems, the curiosity of human, lead him to wonder, *"Can a machine think and behave like humans do?"*

Thus, the development of AI started with the intention of creating similar intelligence in machines that we find and regard high in humans.

What are the uses for AI?

AI is ubiquitous today, used to recommend what you should buy next online, to understand what you say to virtual assistants such as Amazon's Alexa and Apple's Siri, to recognise who and what is in a photo, to spot spam, or detect credit card fraud.

Programming Without and With AI

The programming without and with AI is different in following ways –

Programming Without AI	Programming With AI
A computer program without AI can answer the **specific** questions it is meant to solve.	A computer program with AI can answer the **generic** questions it is meant to solve.
Modification in the program leads to change in its structure.	AI programs can absorb new modifications by putting highly independent pieces of information together. Hence you can modify even a minute piece of information of program without affecting its structure.
Modification is not quick and easy. It may lead to affecting the program adversely.	Quick and Easy program modification.

What are the different types of AI?

At a very high level artificial intelligence can be split into two broad types: narrow AI and general AI.

Narrow AI is what we see all around us in computers today: intelligent systems that have been taught or learned how to carry out specific tasks without being explicitly programmed how to do so.

This type of machine intelligence is evident in the speech and language recognition of the Siri virtual assistant on the Apple iPhone, in the vision-recognition systems on self-driving cars, in the recommendation engines that suggest products you might like based on what you bought in the past. Unlike humans, these systems can only learn or be taught how to do specific tasks, which is why they are called narrow AI.

What can narrow AI do?

There are a vast number of emerging applications for narrow AI: interpreting video feeds from drones carrying out visual inspections of infrastructure such as oil pipelines, organizing personal and business calendars, responding to simple customer-service queries, co-ordinating with other intelligent systems to carry out tasks like booking a hotel at a suitable time and location, helping radiologists to spot potential tumors in X-rays, flagging inappropriate content online, detecting wear and tear in elevators from data gathered by IoT devices, the list goes on and on.

What can general AI do?

Artificial general intelligence is very different, and is the type of adaptable intellect found in humans, a flexible form of intelligence capable of learning how to carry out vastly different tasks, anything from haircutting to building spreadsheets, or to reason about a wide variety of topics based on its accumulated experience. This is the sort of AI more commonly seen in movies, the likes of HAL in *2001* or Skynet in *The Terminator*, but which doesn't exist today and AI experts are fiercely divided over how soon it will become a reality.

A survey conducted among four groups of experts in 2012/13 by AI researchers Vincent C Müller and philosopher Nick Bostrom reported a 50 percent chance that Artificial General Intelligence (AGI) would be developed between 2040 and 2050, rising to 90 percent by 2075. The group went even further, predicting that so-called ' superintelligence' -- which Bostrom defines as "any intellect that greatly exceeds the cognitive performance of humans in virtually all domains of interest" -- was expected some 30 years after the achievement of AGI.

That said, some AI experts believe such projections are wildly optimistic given our limited understanding of the human brain, and believe that AGI is still centuries away.

What is machine learning?

There is a broad body of research in AI, much of which feeds into and complements each other.

Currently enjoying something of a resurgence, machine learning is where a computer system is fed large amounts of data, which it then uses to learn how to carry out a specific task, such as understanding speech or captioning a photograph.

What are neural networks?

Key to the process of machine learning are neural networks. These are brain-inspired networks of interconnected layers of algorithms, called neurons, that feed data into each other, and which can be trained to carry out specific tasks by modifying the importance attributed to input data as it passes between the layers. During training of these neural networks, the weights attached to different inputs will continue to be varied until the output from the neural network is very close to what is desired, at which point the network will have 'learned' how to carry out a particular task.

A subset of machine learning is deep learning, where neural networks are expanded into sprawling networks with a huge number of layers that are trained using massive amounts of data. It is these deep neural networks that have fueled the current leap forward in the ability of computers to carry out task like speech recognition and computer vision.

There are various types of neural networks, with different strengths and weaknesses. Recurrent neural networks are a type of neural net particularly well suited to language processing and speech recognition, while convolutional neural networks are more commonly used in image recognition. The design of neural networks is also evolving, with researchers recently refining a more effective form of deep neural network called long short-term memory or LSTM, allowing it to operate fast enough to be used in on-demand systems like Google Translate

Applications of AI

AI has been dominant in various fields such as –

- **Gaming** – AI plays crucial role in strategic games such as chess, poker, tic-tac-toe, etc., where machine can think of large number of possible positions based on heuristic knowledge.
- **Natural Language Processing** – It is possible to interact with the computer that understands natural language spoken by humans.
- **Expert Systems** – There are some applications which integrate machine, software, and special information to impart reasoning and advising. They provide explanation and advice to the users.
- **Vision Systems** – These systems understand, interpret, and comprehend visual input on the computer. For example,
  - A spying aeroplane takes photographs, which are used to figure out spatial information or map of the areas.
  - Doctors use clinical expert system to diagnose the patient.
  - Police use computer software that can recognize the face of criminal with the stored portrait made by forensic artist.
- **Speech Recognition** – Some intelligent systems are capable of hearing and comprehending the language in terms of sentences and their meanings while a human talks to it. It can handle different accents, slang words, noise in the background, change in human's noise due to cold, etc.
- **Handwriting Recognition** – The handwriting recognition software reads the text written on paper by a pen or on screen by a stylus. It can recognize the shapes of the letters and convert it into editable text.
- **Intelligent Robots** – Robots are able to perform the tasks given by a human. They have sensors to detect physical data from the real world such as light, heat, temperature, movement, sound, bump, and pressure. They have efficient processors, multiple sensors and huge memory, to exhibit intelligence. In addition, they are capable of learning from their mistakes and they can adapt to the new environment.

'Artificial Intelligence' for humanity

Q: What is 'Artificial Intelligence'? How is it helpful for humanity? (CSS-2018)

Artificial Intelligence is a way of **making a computer, a computer-controlled robot, or**

a software think intelligently, in the similar manner the intelligent humans think.

AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.

'Artificial Intelligence' for humanity

Artificial intelligence helps farmers, doctors and rescue workers make a positive impact on society.

Artificial intelligence (AI) powers many gadgets, like smartphones, smart thermostats and voice-activated virtual assistants that bring modern conveniences to daily life. Increasingly, AI is also being used to tackle critical social challenges.

AI is a branch of computer science where machines can sense, learn, reason, act and adapt to the real world, amplifying human capabilities and automating tedious or dangerous tasks.

Artificial Intelligence is already able, as many of us have seen for ourselves, to drive vehicles and negotiate obstacles. This is being used in modern civilian life, and has applications for military operations and space exploration.

Serious success is being seen in the trials of new machinery designed to identify tumours on CT scans and X-rays, and they have performed with at least 50 per cent more accuracy than human experts have so far.

Mining and managing Big Data, as well as discovering important correlations within it, is possible with e-discovery software. This technology is also being used to get through huge mountains of legal documents more effectively and efficiently than human paralegals can. Some journalism jobs like sports summaries and market reports are also already within the scope of AI, as are certain middle management tasks.

As AI continues to develop, it is not only able to take on tasks that can be broken down into smaller, easily learnable steps. There is growing concern that AI may become properly sentient and super-intelligent, displacing humans and rendering them obsolete. Elon Musk, Bill Gates and Stephen Hawking have all opined that this reality is not so far off. The debate on AI's risks and benefits has strong voices on both sides.

Reframing Farming

One of AI's greatest impacts could be in food production — an industry challenged by a rapidly growing world population, competition for natural resources and plateauing agricultural productivity. The Food and Agriculture Organization of the United Nations (FAO) estimates that the earth's population will balloon to 9.7 billion people on by 2050. At a time when the agricultural land available for farming is shrinking, farmers will need to grow approximately 50 percent more crops.

Improving Cancer Diagnosis

Cancer is a frightening diagnosis, impacting 1.65 million people in the U.S. in 2015. Waiting for biopsy results can be stressful, but AI may help accelerate the diagnosis and treatment process. Working with healthcare industry leaders, by 2020 Intel aims to create one-day precision medicine for cancer patients — that means going to the doctor, getting a diagnosis and receiving a personalized treatment plan, all in 24 hours.

Keeping Kids Safe

Digital technology makes it easier for predators to create, access and share child sexual abuse images worldwide. While fear of the negative consequences remain, AI is proving it can bring about enormous societal benefits.

response to AI

The response that human society formulates now to Artificial Intelligence is very portant. The technology is a tool that could enhance our lives in many ways, but we need to tinue to discuss its possibilities for subjective experiences and human emotions, its job placement potential and other important issues, and to manage them responsibly. United States National Science and Technology's Subcommittee on Machine Learning and tificial Intelligence delivered a report to the White House on AI and employment in 2016, knowledging job loss but also emphasising potential new careers and opportunities. onomists, anthropologists and other experts are also teaming up with AI scientists to explore its pact more, such as at a conference to discuss "beneficial AI" held in California in January 2017. Such active awareness and engagement with the issues will remain essential as we move into the future.

Short Notes

Fiber Optics (CSS 2016)

Fiber optics (optical fibers) are long, thin strands of very pure glass about the diameter of a human hair. They are arranged in bundles called **optical cables** and used to transmit light signals over long distances.

If you look closely at a single optical fiber, you will see that it has the following parts:

- **Core** - Thin glass center of the fiber where the light travels
- **Cladding** - Outer optical material surrounding the core that reflects the light back into the core
- **Buffer coating** - Plastic coating that protects the fiber from damage and moisture

Hundreds or thousands of these optical fibers are arranged in bundles in optical cables. The bundles are protected by the cable's outer covering, called a **jacket**.

Optical fibers come in two types:

- **Single-mode fibers**
- **Multi-mode fibers**

The Global Positioning System (GPS) is a satellite-based navigation system made up of at least 24 satellites. GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription fees or setup charges. The U.S. Department of Defense (USDOD) originally put the satellites into orbit for military use, but they were made available for civilian use in the 1980s.

How GPS works (CSS 2016)

GPS satellites circle the Earth twice a day in a precise orbit. Each satellite transmits a unique signal and orbital parameters that allow GPS devices to decode and compute the precise location of the satellite. GPS receivers use this information and trilateration to calculate a user's exact location. Essentially, the GPS receiver measures the distance to each satellite by the amount of time it takes to receive a transmitted signal. With distance measurements from a few more satellites, the receiver can determine a user's position and display it electronically to measure your running route, map a golf course, find a way home or adventure anywhere.

Internet (CSS 2010 / 2011)

The internet in simple terms is a network of the interlinked computer networking worldwide, which is accessible to the general public. These interconnected computers work by transmitting data through a special type of packet switching which is known as the IP or the internet protocol.

Internet is such a huge network of several different interlinked networks relating to the business, government, academic, and even smaller domestic networks, therefore internet is known as the network of all the other networks. These networks enable the internet to be used for various important functions which include the several means of communications like the file transfer, the online chat and even the sharing of the documents and web sites on the WWW, or the World Wide Web.

It is always mistaken said that the internet and the *World Wide Web* are both the same terms, or are synonymous. Actually there is a very significant difference between the two which has to be clear to understand both the terms. The internet and World Wide Web are both the networks yet; the internet is the network of the several different computers which are connected through the linkage of the accessories like the copper wires, the fiber optics and even the latest wireless connections. However, the World Wide Web consists of the interlinked collection of the information and documents which are taken as the resource by the general public. These are then linked by the website URLs and the hyperlinks. Therefore *World Wide Web* is one of the services offered by the whole complicated and huge network of the internet.

The use of IP in the Internet is the integral part of the network, as they provide the services of the internet, through different layers organization through the IP data packets. There are other protocols that are the sub-classes of the IP itself, like the TCP, and the HTTP.

Millennium Bug (CSS 2009)

The millennium bug was a computer problem that threatened the operations of corporations, utility companies, finance industries, government agencies and even science. On the stroke of midnight between 31 December 1999 and 1 January 2000, the fear was that all computers had the potential of shutting down. The millennium bug is also known as the Year 2000 problem, Y2K problem, Y2K bug, and most commonly referred to as simply Y2K.

The millennium bug was specifically a programming problem. It was the result of a combination of a space issue as well as a lack of forward thinking on the part of the programmers back in the 1960s and 1970s. During the beginning stages of computer programming, memory and other storage space were scarce and expensive, so saving characters was a priority.

Programmers were writing business application code using COBOL (common business oriented language) and RPG (report programming generator) to run on mainframes. Programmers stored dates in the form of yymmdd which involved a total of six characters, automatically sorting in an ascending order. Each one of those characters equaled one whole space (byte) of computer storage. Consequently saving two bytes of storage for each date was significant when you consider the amount of date fields stored on cards, tapes, or disks in all the records in all the files in all the computers.

Define the following terms (CSS 2000)

(a) RAM, (b) Byte (c) Mouse (d) Icons (e) Software (f) Control Unit (g) LAN (h) Modem (i) ALU (j) Registers.

RAM

RAM (random access memory) is the place in a computer where the operating system, application programs, and data in current use are kept so that they can be quickly reached by the computer's processor.

Byte

In most computer systems, a byte is a unit of data that is eight binary digits long. A byte is the unit most computers use to represent a character such as a letter, number, or typographic

symbol (for example, "g", "5", or "?")

Mouse

In computing, a **mouse** is a pointing device that functions by detecting two-dimensional motion relative to its supporting surface

Icons

A **computer icon** is a pictogram displayed on a computer screen in order to help user avigate a computer system

Software

Computer software, or just **software,** is any set of machine-readable instructions that directs a computer's processor to perform specific operations

Control Unit

The **control unit** is a component of a computer's central processing unit (CPU) which directs operation of the processor.

LAN

A **local area network (LAN)** is a computer network that interconnects computers in a limited area such as a home, school, computer laboratory, or office building using network media

Modem

A modem is a device that modulates an analog carrier signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information.

ALU

Stands for "Arithmetic Logic Unit." An ALU is an integrated circuit within a CPU or GPU that performs arithmetic and logic operations.

Register (CSS 1998/2000)

In a computer, a register is one of a small set of data holding places that are part of a computer processor.

Misc Solved Questions from Past CSS Papers

Q: Describe different steps to digest Carbohydrate in the human body. (CSS 2018)

The main function of carbohydrates is to provide your body with energy to support muscular work, brain activity, breathing and other important activities. Carbohydrates are made up of sugars known as saccharides. Most carbohydrate foods contain many saccharides linked together, which are known as polysaccharides. Carbohydrate digestion begins in the mouth and is complete when the polysaccharides are broken down into single sugars, or monosaccharides, which can be absorbed by the body.

Mouth

Carbohydrate digestion begins in the mouth. The salivary glands in the mouth secrete saliva, which helps to moisten the food. The food is then chewed while the salivary glands also release the enzyme salivary amylase, which begins the process of breaking down the polysaccharides in the carbohydrate food.

Stomach

After the carbohydrate food is chewed into smaller pieces and mixed with salivary amylase and other salivary juices, it is swallowed and passed through the esophagus. The mixture enters the stomach where it is known as chyme. There is no further digestion of chyme, as the stomach produces acid which destroys bacteria in the food and stops the action of the salivary amylase.

Pancreas and Small Intestine

After being in the stomach, the chyme enters the beginning portion of the small intestine, or the duodenum. In response to chyme being in the duodenum, the pancreas releases the enzyme pancreatic amylase, which breaks the polysaccharide down into a disaccharide, a chain of of only two sugars linked together. The small intestine then produces enzymes called lactase, sucrase and maltase, which break down the disaccharides into monosaccharides. The monosaccharides are single sugars that are then absorbed in the small intestine.

Large Intestine (Colon)

Carbohydrates that were not digested and absorbed by the small intestine reach the colon where they are partly broken down by intestinal bacteria. Fiber, which cannot be digested like other carbohydrates, is excreted with feces or partly digested by the intestinal bacteria.

Q: Explain in details the common causes of Heart Attack. (CSS 2017)

Heart attacks are caused by the blood supply to the heart being suddenly interrupted.

Without this supply, heart muscles may be damaged and begin to die.

Without treatment, the heart muscles will experience irreversible damage.

If a large portion of the heart is damaged in this way, the heart stops beating (known as a cardiac arrest), resulting in death.

Coronary heart disease

Coronary heart disease (CHD) is the leading cause of heart attacks. CHD is a condition in which the coronary arteries (the major blood vessels that supply the heart with blood) get clogged up with deposits of cholesterol. These deposits are called plaques.

Before a heart attack, one of the plaques ruptures (bursts), causing a blood clot to develop at the site of the rupture. The clot may block the supply of blood to the heart, triggering a

heart attack.

Your risk of developing CHD is increased by:

- smoking
- a high-fat diet
- diabetes
- high cholesterol
- high blood pressure
- being overweight or obese

Less common causes

Some less common causes are described below.

Drug misuse

Stimulants such as cocaine, amphetamines (speed) and methamphetamines (crystal meth) can cause coronary arteries to narrow, restricting blood supply and triggering a heart attack.

Heart attacks from the use of cocaine are one of the most common causes of sudden death in young people.

Lack of oxygen in the blood (hypoxia)

If levels of oxygen in the blood decrease due to carbon monoxide poisoning or a loss of normal lung function, the heart will receive un-oxygenated blood.

This will result in the heart muscles being damaged, triggering a heart attack.

Q: Difference between drug addiction and drug abuse (CSS 2017)

While many people use the terms drug *abuse* and *addiction* interchangeably, abuse and addiction have separate and distinct meanings. One can abuse drugs without necessarily being addicted to drugs. The drug abuse definition centers more around the way a person uses drugs, while the drug addiction definition includes the use of drugs and also the psychological and physiological effects the drug has on the body.

It's important to understand the drug abuse and drug addiction definitions so as to correctly identify problem behaviors seen in loved ones. It's also key to remember that alcohol is also a drug and is included in the definitions of drug abuse and addiction.

Drug Abuse and Addiction - Drug Tolerance

Central to the understanding of drug abuse and addiction is the idea of tolerance. When a person starts using a drug, they typically use a small amount to receive pleasurable effects, or a "high." With time though, drug users find the same amount of drug no longer produces the desired effects and they have to consume more of the drug to attain the same high. This effect is known as *tolerance*.

In drug abuse and addiction, creation of tolerance depends on the drug used, the amount that is used and the frequency with which it is used. Drug tolerance can be both psychological and physiological.

Drug Abuse Definition

The definition of *drug abuse* does not have *drug tolerance* as a factor. Rather, it focuses on the pattern of drug use and the effects drugs are having on a user's life. Drug abuse and addiction takes place over time, but the definition of drug abuse specifically requires that drugs have negative effects on the user's life over a 12-month period. The following are drug abuse symptoms:

- Drug use has negatively impacted performance in work or school

- Risky acts endangering the drug user or others are committed as a result of drug use, for example, drinking and driving
- Continuation of drug use in spite of the negative consequences drug use is having on relationships
- Legal or financial problems as a result of drug use
- A drug user may match the drug abuse definition even if only one of the symptoms is present. Drug abuse frequently, but not always, leads to drug addiction.

Drug Addiction Definition

The definition of *drug addiction* contains aspects of the drug abuse definition in that the user is experiencing negative consequences from drug use and refuses to quit using the drug. However, with drug addiction, the addict has developed a tolerance to the drug, increasing the used amount, and experiences withdrawal symptoms when abstinent. In addition to drug tolerance, here are other drug addiction symptoms:

- Experiencing withdrawal symptoms when not using the drug
- Is unable to stop using the drug even after repeated attempts to do so
- Consumes large and even dangerous amounts of the drug

While the term "drug addiction" is commonly known, it is not used in the *Diagnostic and Statistical Manual of Mental Disorders (DSM)*. Instead, the DSM defines substance dependence similarly to the drug addiction definition above.

***Q:* Comment, "liver is the chief chemist in human body'** (CSS 2016)

The liver is the "chief chemist" of the body in that it performs more than 500 functions including the elimination of toxins. The liver is largely responsible for eliminating the toxins we ingest through the food we eat, the water we drink and the air we breathe. The liver is also responsible for eliminating the toxins generated by any pharmaceutical drugs we may be taking.

The liver is a four-lobed, triangular-shaped organ weighing a little more than 3 pounds. It is the largest gland in the human body, according to Procto-med.com. The liver is part of the gastrointestinal system and is located in the upper abdomen to the right of the stomach. The liver carries out many functions necessary for survival, including processes of metabolism, digestion and cleansing of the blood.

Detoxification

The cells of the liver contain thousands of enzymes for use in the chemical reactions of metabolism, according to the University of Nottingham. People consume various toxins from foods, drugs and water daily. A healthy liver is capable of transforming potentially harmful substances, such as drugs and alcohol, into harmless products to be eliminated in the bile or urine

Nutrient Processing

Nutrients consumed in the diet travel from the intestine to the liver and are processed into substances that the body's tissues can use, the Gastroenterological Society of Australia reports. The liver synthesizes, stores and releases nutrients into the blood based on the body's needs.

Cholesterol Production

Each day, the liver makes about 1,000 milligrams of cholesterol, which is used for production of hormones, Vitamin D and bile.

Protein Synthesis

The liver makes certain proteins necessary for blood clotting and for transporting nutrients such as iron, according to Brown University. Many blood proteins are also needed for water balance in the body. Additionally, the liver produces proteins involved in the functioning of the immune system.

Bile Production

The liver produces bile, which is stored in the gall bladder. Bile aids in the digestion of fats and assists with elimination of toxins from the body.

Storage

Many nutrients are stored in the liver, including certain fats, Vitamin B12, iron, copper and the fat-soluble vitamins A, D and K. The liver also stores glycogen, the storage form of glucose.

Blood Sugar Regulation

The body must maintain blood glucose within a particular range. When blood glucose falls too far, the liver can convert stored glycogen back to glucose, or it can make glucose from amino acids to raise blood glucose to a normal level.

***Q:* What is hydrological cycle? Discuss its importance.** (CSS 2016)

What is the hydrologic cycle?

The hydrologic -- or water -- cycle is the continuous movement of water between the earth and the atmosphere. Water reaches land as precipitation such as rain and snow. Then the water evaporates, condenses in the atmosphere to form clouds, and falls to the earth again as precipitation, continuing the cycle.

When water falls to the ground it can collect on the land becoming streams, rivers, lakes, or soaks in to the ground to become groundwater. Plants take up groundwater either using it or releasing it to the atmosphere.

Why is the hydrologic cycle important?

The hydrologic cycle is important because it is how water reaches plants, animals and us! Besides providing people, animals and plants with water, it also moves things like nutrients, pathogens and sediment in and out of aquatic ecosystems.

Ways in which the hydrologic cycle is affected

One of the ways that water moves through the cycle is through its ability to permeate, or soak, into the soil. There are four key areas that impact that part of the cycle:

1. changes in the ability of soil to soak up water through increases of impervious surfaces, like roads and buildings, and removal of forest cover;
2. water withdrawals or impoundments (such as through wells or dams)
3. filling depressional wetlands;
4. and altering stream flows and beds.

***Q:* What is Nanotechnology and what is its use?** (CSS 2013)

Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers (nm), where unique phenomena enable novel applications not feasible when working with bulk materials or even with single atoms or molecules. A nanometer is one-billionth of a meter. A sheet of paper is about 100.000 nanometers thick; a single gold atom is about a third of a nanometer in diameter Researchers seeking to understand the fundamentals of properties at the nanoscale call their work nanoscience; those focused on effective use of the properties call their work *nanoengineering.*

Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at the nanoscale.

The ideas and concepts behind nanoscience and nanotechnology started with a talk entitled "There's Plenty of Room at the Bottom" by physicist Richard Feynman at an American Physical Society meeting at the California Institute of Technology (CalTech) on December 29, 1959, long before the term nanotechnology was used. In his talk, Feynman described a process in which scientists would be able to manipulate and control individual atoms and molecules. Over a decade later, in his explorations of ultraprecision machining, Professor Norio Taniguchi coined the term nanotechnology. It wasn't until 1981, with the development of the scanning tunneling microscope that could "see" individual atoms, that modern

Applications *of* Nanotechnology

- Nanotechnology is used in many commercial products and processes, for example, nanomaterials are used to manufacture lightweight, strong materials for applications such as boat hulls, sporting equipment, and automotive parts. Nanomaterials are also used in sunscreens and cosmetics.
- Nanostructured products are used to produce space-saving insulators which are useful when size and weight is at a premium
- In healthcare, nanoceramics are used in some dental implants or to fill holes in diseased bones, because their mechanical and chemical properties can be "tuned" to attract bone cells from the surrounding tissue to make new bone. Some pharmaceutical products have been reformulated with nanosized particles to improve their absorption and make them easier to administer. Opticians apply nanocoatings to eyeglasses to make them easier to keep clean and harder to scratch and nanoenabled coatings are used on fabrics to make clothing stain-resistant and easy to care for
- Almost all high-performance electronic devices manufactured in the past decade use some nanomaterials. Nanotechnology helps build new transistor structures and interconnects for the fastest, most advanced computing chips

***Q:* Why MRI is preferred over CT scan?** (CSS 2013 Fsd ReExam)

MRI and CT are very different and used for different needs and reasons; both are valuable and both have specific applications; they are not interchangeable and one is not a better test than the other for all things

CT scan does not show our tendons and ligaments very well at all; at least not yet. MRI is the best choice for that. Tendons and ligaments around the shoulder and knee are best seen by the physics used in MRI. This is due to the density of the tissues that compose the tendons and ligaments.

Spinal cord is best seen by MRI for the same reason. The density of the spinal cord and the composition of it is such that MRI physics can show it to us much better than CT.

The difference in the way the images are produced in MRI vs CT is the physics involved. CT scan uses an x-ray beam that slices through you like a knife carving a spiral ham.

MRI (magnetic resonance imaging) uses a magnetic field with radio frequencies introduced into it. When your body is placed inside the magnetic field, the molecules of water in your body (hydrogen molecules) will start to spin like a kid's top when he spins it. The top will

begin to wobble as it slows down.

***Q:* Briefly Describe the Role of Nitrogen, Phosphorous and Potassium in the Growth of Plants** (CSS 2013 Fsd ReExam)

Nitrogen promotes plant growth. It is associated with leafy, vegetative growth. It's part of every protein in the plant, so it's required for virtually every process, from growing new leaves to defending against pests. Nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis. Lack of nitrogen shows up as general yellowing (chlorosis) of the plant. Because nitrogen can move around in the plant, older growth often yellows more than the new growth. Phosphorus is involved in metabolic processes responsible for transferring energy from one point to another in the plant. It's also critical in root development and flowering. Because phosphorus moves slowly through the soil, it's important to work it into the soil, where it's needed by the roots. Potassium helps regulate plant metabolism and affects water pressure regulation inside and outside of plant cells. It is important for good rood development. For these reasons, potassium is critical to plant stress tolerance.

***Q:* Why long exposure of human skin to the sunlight is dangerous? Is there any positive impact of radiations?** (CSS 2013 Fsd ReExam)

Long-term sunlight exposure is known to be associated with the development of skin cancer, skin aging, immune suppression and eye diseases such as cataracts. Sun exposure has also been associated with the timing of melatonin synthesis and reduced risk of seasonal affective disorder. A number of public health organizations state that there needs to be a balance between the risks of having too much and the risks of having too little sunlight. There is a general consensus that sunburn should always be avoided

Sunburn (or erythema) is redness of the skin, which is due to increased blood flow in the skin caused by dilatation of the superficial blood vessels in the dermis as a result of exposure to UV radiation. High UV doses may also results in edema, pain, blistering, and peeling of the skin a few days following exposure. UV-B radiation is believed to be mainly responsible for sunburn as it is more erythmogenic by a factor of 1,000, however since there is more UV-A radiation reaching the earth's surface, UV-A contributes 15-20% to the sunburn reaction in the summer months. Risk factors for sunburn include fair skin, red or blond hair, blue eyes, and freckles. For people with fair skin, it takes only 15-30 minutes in midday sun to induce erythema. In terms of areas of the body that are more susceptible to sunburn, the face, neck, and trunk are two to four times more sensitive than the limbs. In addition, children and the elderly are believed to be more sensitive to UV radiation and may burn more easily. A sunburn reaches its maximum redness eight to 12 hours after exposure and fades within one to two days (1).

Is there any positive impact of radiations?

The ultraviolet radiation in sunlight, though a principal source of vitamin D3 compared to diet, is mutagenic. Supplementing diet with vitamin D3 supplies vitamin D without this mutagenic effect, but bypasses natural mechanisms that would prevent overdoses of vitamin D generated internally from sunlight. Sunlight is the major source of vitamin D-producing Ultraviolet B radiation, which has a wide range of positive health effects, including possibly inhibiting the growth of some cancers

There is some evidence that bright light exposure reduces seasonal affective disorder, and it is a standard treatment for certain circadian rhythm sleep disorders. There is a research on the possibility of sun exposure reducing hypertension and the incidence of cardiac disease. According to the experiments of Dr. Richard Weller, the skin acts as storage for nitric oxide, NO, which is released to the blood upon UV exposure

Q: Why DDT once labelled as a Miracle is now being considered an Environmental Tragedy? (CSS 2013 Fsd ReExam)

DDT is a pesticide discovered in 1939 by Paul Müller, a lifesaving scientist It was world widely used to wipe out malaria by killing the mosquitoes that carry the disease. Its reputation problem began in the 1960s when Rachel Carson wrote *Silent Spring*, saying that pesticides such as DDT were ruinous to wildlife.

In her successful book *Silent Spring* (1962), Rachel Carson explained the environmental damages derived from the use of DDT. Carson predicted that, if the use of DDT continued, all the birds in the world would disappear. Once Carson's studies were ratified by other biologists and scientists, the U.S. Environmental Protection Agency (EPA) banned the use of DDT in 1972.

DDT and the environment

Among the diverse effects of DDT on the health of animals, many highlight:

- Problems in reproduction and development.
- Possible defects on the immune system and premature death of birds.
- Effects on the liver and kidney.
- Block of sexual development in many animals, during several studies.
- Reduction in the quality and quantity of microscopic animals in phytoplankton, a fundamental pillar of the marine food chain.
- DDT has been detected in animals in the Arctic, clear proof of the action and influence on the development of life on the planet.

DDT was excluded from the list of authorized substances for protection of plants and pest control. Now, the ban extends to the production, user and sale of all plant protection products that contain DDT.

In 2006 the World Health Organization announced that it would return to using DDT as an insecticide to eradicate malaria (and to kill the mosquitos that transmit the disease).

Although this international organization considers that its use isn't harmful to nature and, instead, effective in the prevention of this disease, its use continues to be controversial.

Q: Why people have switched to Vegetable Oil for cooking instead of Saturated Fats? (CSS 2013 Fsd ReExam)

Vegetable oils (and margarine, made from these oils) are oils extracted from seeds like the rapeseed (canola oil) soybean (soybean oil), corn, sunflower, safflower, etc.

Our body needs Omega-3 and Omega-6 fats in balance, preferably a 1:1 ratio. Most people consume a much higher ratio of Omega-6 fats, and this can lead to problems. Vegetable oils contain a very high concentration of Omega 6 fatty acids and polyunsaturated fats, which cause an imbalance of these oils in the body. Omega 6 fats are easily oxidized with heat or light exposure. This is another reason that when these types of fats/oils are incorporated into tissue like skin cells, the heat and light from sun exposure can increase skin cancer risk.

Most vegetable oils and their products contain BHA and BHT (Butylated Hydroxyanisole and Butylated Hydroxytoluene) which are artificial antioxidants that help prevent food from oxidizing or spoiling too quickly.

These chemicals have been shown to produce potential cancer causing compounds in the body, and have also been linked to liver/kidney damage, immune problems, infertility or sterility, high cholesterol, and behavioral problems in children.

Vegetable oils are extremely damaging to the reproductive system and the developing bodies of unborn babies and children. Because the reproductive system in both men and women is constantly producing and dividing new cells, there is potential for mutation and problems when these cells are made of the wrong kind of fats and are oxidized.

Q: Briefly explain the differences between Chemotherapy and Radiotherapy (CSS 2013)

Chemotherapy and radiation therapy are two of the most effective treatment approaches for cancer.

Chemotherapy refers to a chemical or drug given to destroy cancer cells. Chemotherapy is prescribed by a medical oncologist. Because the chemo drug is given through an intravenous (IV) injection, it spreads throughout the entire bloodstream. This type of treatment is effective because it kills cancer cells that have spread beyond the initial affected tissue or organ. On the other hand, as the drug spreads through the bloodstream killing cancer cells, it also has effects on other rapidly dividing cells such as those in your blood, mouth, nose, nails, vagina, intestinal tract and hair. This can cause patients to feel ill after treatment and lose their hair.

Radiation therapy is a local high energy X-ray treatment, focusing only on the areas affected by cancer. Radiation treatments are prescribed by a radiation oncologist. The radiation does not travel through the bloodstream so it does not have systemic side effects. Typically, side effects caused by radiation will only affect the direct area that is treated. Radiation therapy is commonly used for treating cancer of the head and neck, breast, bladder, lung, prostate, brain and Hodgkin lymphoma.

Q: Is it HDL or LDL which is Harmful to Human Health and Why? (CSS 2013 Fsd ReExam)

There are two kinds of cholesterol – HDL (high density lipoprotein) and LDL (low density lipoprotein). HDL is the good cholesterol that keeps LDL, the bad cholesterol, down

Too much LDL cholesterol can cause deposits to build up in the blood vessels, known as plaque, which decreases the amount of blood and oxygen going to the heart. This in turn can lead to heart disease and heart attack.

Q: Porifera *(Sponges)* is an ancient group of animals from Cambrian period. What is the cause of their survival/success? (CSS 2013)

Sponges belong to the phylum **Porifera** in the animal kingdom. The main reasons they are placed into this phylum is due to the presents of numerous holes called pores. Sponges, phylum Porifera, are the oldest metazoan group still extant on our planet. Their continued survival in vast numbers in recent seas (*and in freshwater habitats*) is closely linked to the apparent adaptability of their bauplan to dramatic changes in environmental characteristics and competing biota

These animals have other characteristics that make them unique members of the animal kingdom. They are filter feeders. Since these animals do not move (*sessile*) they must gather food by filtering it out of the water as it flows through it. Special cells called *collar cells* pick up the planktonic food and start the digestive process.

They contain *spicules*. These structures are small bone like particles made out of *calcium carbonate* or *silicon dioxide*. They function in support and protect these animals from danger.

They reproduce through the process of budding where an adult will grow an offspring from it side. These buds can remain attached to the parent or break off and take up residence elsewhere. Sponges are also know to regenerate lost body parts. Sexual reproduction is limited. Structures called *gemmules* are formed from *amebocytes* and *spicules* during environmental stress.

Knowledge of sponge biodiversity is still largely incomplete. To date, about 11,000 species have been formally described of which approximately 8,500 are considered valid (see below), but as many as twice that number are thought to exist. Sponges are currently divided among four distinct classes, 25 orders, 128 families and 680 genera *Most modern sponge species are Leuconoid.*

Q: State the message of "The Earth Hour Movement". (CSS 2013)

"The message for this mass movement is simple — for individuals, organisations and governments to act against climate change by switching off non-essential lights for one hour from 8.30pm to 9.30pm."

Earth Hour **2014** *is scheduled for Saturday, March 29, from 8:30 p.m. to 9:30 p.m. during participants' local time.*

I Will If You Will (IWIYW) is an Earth Hour campaign to encourage positive action for the environment, beyond the hour. What makes it special is that it empowers you - as an individual or as part of a community or organisation - to share your commitment to the planet with friends, family, colleagues, fans or even a whole nation.

The idea is simple. Someone makes a promise to do something if a certain number of people commit to take an ongoing action for the environment, beyond Earth Hour.

The action could be big or small; it might be a simple lifestyle change or maybe something that leads to political change. It might require 10 people to do something, or 10,000. The point is that I Will If You Will allows anybody – from a kid in a classroom to a President of a nation - to become the inspiration to their friends, family, colleagues and communities by sharing what they're willing to do to protect the planet.

***Q:* Very briefly explain the difference between Earthquakes, volcanic eruptions, floods and tsunamis.** (CSS 2012)

Earthquakes, volcanic eruptions, tsunami are Geological Hazards

Floods are Weather Associated Hazard

***Q:* Briefly explain the difference between Sedimentary and Metamorphic rocks.** (CSS 2012)

Sedimentary rocks and metamorphic rocks have some differences between them.

- Formation of *metamorphic rocks* might involve with heat from magma, while it is not so with *sedimentary rocks.*
- *Sedimentary rocks* are formed in the earth surface, while *metamorphic rocks* are formed deep in the earth.
- *Sedimentary rocks* often contain fossils, while *metamorphic rocks* rarely have fossils.
- *Sedimentary rocks* usually have pores between pieces, but *metamorphic rocks* rarely have pores or openings.
- *Metamorphic rocks* may have bent or curved foliation, while *sedimentary rocks* often have layers.
- *Metamorphic rocks* are harder than *sedimentary rocks.*

Briefly explain the difference between a LASER and a Photovoltaic Cell. (CSS 2012)

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation

A solar cell (also called a *photovoltaic cell* or *photocell*) is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect.

***Q:* Briefly explain the Nitrogen Cycle in nature.** (CSS 2012)

Nitrogen is a component of many organic molecules. It forms an essential part of amino acids (which make up proteins) and DNA. Nitrogen is essential for all living cells.

Nitrogen is the major component of earth's atmosphere. It enters the food chain by means of nitrogen-fixing bacteria and algae in the soil. This nitrogen which has been 'fixed' is now available for plants to absorb. These types of bacteria form a symbiotic relationship with legumes--these types of plants are very useful because the nitrogen fixation enriches the soil and acts as a 'natural' fertilizer. The nitrogen-fixing bacteria form nitrates out of the atmospheric nitrogen which can be taken up and dissolved in soil water by the roots of plants. Then, the nitrates are incorporated by the plants to form proteins, which can then be spread through the food chain. When organisms excrete wastes, nitrogen is released into the environment. Also, whenever an organism dies, decomposers break down the corpse into nitrogen in the form of ammonia. This nitrogen can then be used again by nitrifying bacteria to fix nitrogen for the plants.

***Q:* Briefly explain the difference between an Antibiotic, an Antiviral Drug** (CSS 2012)

Antivirals kill viruses, and antibiotics kill bacteria. Both of these medicines are called antimicrobials.

There are many more types of antibiotics than antivirals. Bacteria are relatively simple in terms of their makeup and construction, so it's easier to develop drugs to target them.

On the other hand, antivirals are difficult to develop. Viruses are tricky. They change frequently, so even when you think you've got a handle on a virus, it can mutate and turn into a cousin of its original self.

While drug resistance is a problem with both of these antimicrobials, viruses can become resistant quickly, while bacteria resistance can sometimes take years.

Probably the best-known antiviral right now is Tamiflu, which targets flu viruses. It's most effective when given within 48 hours of the onset of symptoms, and it decreases the duration of symptoms by about 1.25 days.

***Q:* Function of Mitochondria.** (CSS 2011)

The main function of the mitochondrion is the production of energy, in the form of adenosine triphosphate (ATP). The cell uses this energy to perform the specific work necessary for cell survival and function.Other functions of mitochondria are related to the cell type in which they are found. Mitochondria are involved in building, breaking down, and recycling products needed for proper cell functioning. For example, some of the building blocks of DNA and RNA occur within the mitochondria. Mitochondria are also involved in making parts of blood and hormones such as estrogen and testosterone. They are required for cholesterol metabolism, neurotransmitter metabolism, and detoxification of ammonia in the urea cycle. Thus, if mitochondria do not function properly, not only energy production but also cell-specific products needed for normal cell functioning will be affected.

Q: Functions of Golgi. (CSS 2011)

A major organelle in most eukaryotic cells is the structure of membrane-bound sacs called the Golgi apparatus (*or Golgi body, Golgi complex, dictyosome*). It acts to process and package the macromolecules such as proteins and lipids that are synthesized by the cell. It has been likened to the cell's post office.

The Golgi Apparatus have various functions in an organ. These organelles are responsible for; processing of proteins generated in endoplasmic reticulum and packaging them, transport of lipids around the cell, and the creation of lysosomes among other various functions.

Q: Plaster of Paris (CSS 2010)

Plaster of Paris is a white powder made of gypsum. It got its name because the gypsum is present in large amount in the Paris. Plaster of Paris is abuilding material made up of calcium sulphate hemihydrates. It is produced byheating gypsum to about 150 degree Celsius. It is a dry powder mixed with water and gets hardens. This becomes soft after drying. Plaster of Paris has widevariety of uses in the architecture field

Q: Pacemaker (CSS 2010)

A pacemaker is a small device that's placed in the chest or abdomen to help control abnormal heart rhythms. This device uses electrical pulses to prompt the heart to beat at a normal rate. Pacemakers are used to treat arrhythmias Arrhythmias are problems with the rate or rhythm of the heartbeat. During an arrhythmia, the heart can beat too fast, too slow, or with an irregular rhythm. A pacemaker can relieve some arrhythmia symptoms, such as fatigue and fainting. A pacemaker also can help a person who has abnormal heart rhythms resume a more active lifestyle.

Q: Differentiate between Flying mammal and Bird (CSS 2010)

Flying mammals won't lay eggs and gives birth to young ones and birds lay eggs

The bats are the representative animal of this group. The bat is the only mammal that has 'true' flight. All other 'flying' mammals are gliders. Bats have many unusual characteristics. They cannot walk very well because skin that reaches over its front and back legs. It flies at night and stays in caves and other dark places during the day, hanging upside down by the claws of its back legs. They look like flying mice.

Bats eat insects, although the vampire bat drinks blood. Bats fly in total darkness and have keen hearing. They listen for sounds and echoes to guide their flight. Bats can be helpful in eating insects but can be harmful as they can carry such germs as rabies.

Q: Sino- Auricular Node (CSS 2010)

The Sinoatrial node (SA node) is the impulse-generating (pacemaker) tissue located in the right atrium of the heart, and thus the generator of sinus rhythm. It is a group of cells positioned on the wall of the right atrium, near the entrance of the superior vena cava. In other words, the SA node initiates the heartbeat. Also called *sinoauricular node, sinus node*.

Q: Differentiate between Magma and Lava (CSS 2009)

Magma is composed of molten rock and is stored in the Earth's crust. Lava is magma that reaches the surface of our planet through a volcano vent.

Magma is the molten material beneath the Earth's crust. It usually collects in a magma chamber beneath a volcano, and can then be injected into cracks in rocks or issue out of volcanoes in eruptions. The temperature of magma ranges between 700 C and 1300 C.

When it reaches the surface and comes out of a volcano, magma becomes lava.

Q: Difference between Myopia and Hyperopia (*Hypermetropia*) (CSS 2009)

Myopia is the term used to define short sightedness. Light from a distant object forms an image before it reaches the retina. This could be because the eye is too long, or the cornea or crystalline lens is too strong.

A myopic person has clear vision when looking at objects close to them, but distant objects will appear blurred.

Myopia is easily corrected at your local Vision Express optician using prescription glasses or contact lenses specifically designed to counteract the effect. A concave lens (minus powered) is placed in front of a myopic eye, moving the image back to the retina and clarifying the image.

Hypermetropia means long sight and is where the image of a nearby object is formed behind the retina. This could be because the eye is too short, or the cornea or crystalline lens does not refract the light enough.

A hypermetropic person may have blurred vision when looking at objects close to them, and clearer vision when looking at objects in the distance. By placing a convex (plus powered) lens in front of a hypermetropic eye, the image is moved forward and focuses correctly on the retina.

Q: Write briefly (*not more than three to four senetences*) about Aqua regia (CSS 2009)

Aqua regia is a mixture of hydrochloric acid (HCl) and nitric acid (HNO_3) at a ratio of either 3:1 or 4:1.

Aqua regia is useful to dissolve gold.

Also Known As: royal water, *nitrohydrochloric acid*

Q: Why do dogs pant *and* birds open their mouth *and* elephants flap their ears? (CSS 2009)

The reason why dogs and birds pant through their mouths and elephants flap their large ears, is to control (reduce) their temperature. Some animals can sweat through their skins and cool themselves as this sweat evaporates from their skin. However dogs, birds and elephants (and perhaps some other animals) can not sweat so they either evaporate water in their mouths or pump blood into their 'radiator' sized ears to cool themselves.

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Part-II
(General Ability)

Basic Mathematical Skills

Introduction

We use ten symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 called digits to represent any number. This is the decimal system where we use the numbers 0 to 9. 0 is called insignificant digit whereas 1, 2, 4, 5, 6, 7, 8, 9 are called significant digits.

A group of figures, denoting a number is called a numeral. For a given numeral, we start from extreme right as Unit's place, Ten's place, Hundred's place and so on.

We represent the number 309872546 as shown below:

Ten Crore 10^8	Crores 10^7	Ten Lacs 10^6	Lacs 10^5	Ten Thousand 10^4	Thousand 10^3	Hundred 10^2	Ten's 10^1	Units 10^0
3	0	9	8	7	2	5	4	6

We read it as

"Thirty crores, Ninety-eight lacs, seventy-two thousands five hundred and forty-six."

In this numeral:

The place value of 6 is $6 \times 1 = 6$

The place value of 4 is $4 \times 10 = 40$

The place value of 5 is $5 \times 100 = 500$

The place value of 2 is $2 \times 1000 = 2000$ and so on.

The face value of a digit in a number is the value itself wherever it may be.

Thus, the face value of 7 in the above numeral is 7. The face value of 6 in the above numeral is 6 and so on.

Number System

Natural Numbers

Counting numbers 1, 2, 3, 4, 5, ... are known as natural numbers.

The set of all natural numbers can be represented by N = { 1, 2, 3, 4, 5, ... }.

Whole Numbers

If we include 0 among the natural numbers, then the numbers 0, 1, 2, 3, 4, 5..... are called whole numbers.

The set of whole numbers can be represented by

W= {0, 1, 2, 3, 4, 5. ...} Clearly, every natural number is a whole number but 0 is a whole number which is not a natural number.

Integers

All counting numbers and their negatives including zero are known as integers.

The set of integers can be represented by

Z or I = {... -4, -3, -2, -1, 0, 1, 2, 3, 4, ...}

Positive Integers

The set I^+ = {1, 2, 3, 4.....} is the set of all positive integers. Clearly, positive integers and natural numbers are synonyms.

Negative Integers

The set $I^{-} = \{-1, -2, -3 \ldots\ldots\ldots\}$ is the set of all negative integers. 0 is neither positive nor negative.

Non-negative Integers

The set $\{0, 1, 2, 3, \ldots\}$ is the set of all- non-negative integers.

Rational Numbers

The numbers of the form $\frac{p}{q}$ where p and q are integers and $q \neq 0$ are known as rational numbers, e.g. $\frac{4}{7}, \frac{3}{2}, \frac{5}{8}, \frac{0}{1}, \frac{2}{3}, etc$

The set of all rational numbers is denoted by Q.

$$i.e. Q = \left\{ x : x = \frac{p}{q}; p, q \in I, q \neq 0 \right\}$$

Since every natural number "a" can be written as $\frac{a}{1}$ every natural number is a rational number. Since 0 can be written as $\frac{0}{1}$ and every non-zero integer "a" can be written as $\frac{a}{1}$ every integer is a rational number.

Irrational Numbers

Those numbers which when expressed in decimal form are neither terminating nor repeating decimals are known as irrational numbers, e.g. $\sqrt{2}, \sqrt{3}, \sqrt{5}, \pi, etc$

Note that the exact value of π n is not $\frac{22}{7}$, $\frac{22}{7}$ is rational while π is irrational number. $\frac{22}{7}$ is approximate value of it. Similarly. 3.14 is not an exact value of it.

Real Numbers

The rational and irrational numbers combined together are called real numbers, e.g. $\frac{13}{21}, \frac{2}{5}, -\frac{3}{7}, \sqrt{3}, 4+2\sqrt{2}$ etc. are real numbers.

The set of all real numbers is denoted by R.

Note that the sum difference or product of a rational and irrational number is irrational. e.g. $3+\sqrt{2}, 4-\sqrt{3}, \frac{2}{5}-\sqrt{5}, 4\sqrt{3}, -7\sqrt{5}$ are all irrational.

Even Numbers

All those numbers which are exactly divisible by 2 are called even numbers, e.g.,. 2. 6. 8. 10. etc. are even numbers.

Odd Numbers

All those numbers which are not exactly divisible by 2 are called odd numbers, e.g.. 1. 3. 5. 7 etc.. are odd numbers.

ime Numbers

A natural number other than 1. is a prime number if it is divisible by 1 and itself only.

For example, each of the numbers 2. 3. 5. 7 etc., are prime numbers.

mposite Numbers

Natural numbers greater than 1 which are not prime, are known as composite numbers.

For example, each of the numbers 4, 6, 8, 9, 12, etc., are composite numbers.

ote:

1) The number 1 is neither a prime number nor a composite number.
2) 2 is the only even number which is prime.
3) Prime numbers up to 100 are:

2. 3, 5. 7, 11, 13, 17, 19. 23, 29, 31, 37. 41, 43, 47, 53, 59, 61. 67. 71. 73, 79, 83. 89, 97. i.e.. 25 prime numbers between 1 and 100.

4) Two numbers which have only 1 as the common factor are called co-primes or relatively prime to each other, e.g.. 3 and 5 are co-primes.

Note that the numbers which are relatively prime need not necessarily be prime numbers, e.g. 16 and 17 are relatively prime although 16 is not a prime number.

Tests of Divisibility

1) **Divisibility by 2** A number is divisible by 2 if the unit's digit is zero or divisible by 2.
For example. 4. 12. 30. 18. 102. etc.. are all divisible by 2.

2) **Divisibility by 3** A number is divisible by 3 if the sum of digits in the number is divisible by 3.
For example, the number 3792 is divisible by 3 since 3 +7 + 9 + 2=21, which is divisible by 3.

3) **Divisibility by 4** A number is divisible by 4 if the number formed by the last two digits (ten's digit and unit's digit) is divisible by 4 or are both zero.
For example, the number 2616 is divisible by 4 since 16 is divisible by 4.

4) **Divisibility by 5** A number is divisible by 5 if the unit's digit in the number is 0 or 5.
For example. 13520. 7805,640, 745. etc.. are all divisible by 5.

5) **Divisibility by 6** A number is divisible by 6 if the number is even and sum of its digits is divisible by 3.
For example, the number 4518 is divisible by 6 since it is even and sum of its digits 4 + 5 + 1 + 8 - 18 is divisible by 3.

6) **Divisibility by 7** The unit digit of the given number is doubled and then it is subtracted from the number obtained after omitting the unit digit. If the remainder is divisible by 7, then the given number is also divisible by 7.
For example, consider the number 448. On doubling the unit digit 8 of 448 we get 16. Then. 44- 16 - 28.
Since 28 is divisible by 7, 448 is divisible by 7.

7) **Divisibility by 8** A number is divisible by 8, if the number formed by the last 3 digits is divisible by 8.
For example, the_number 41784 is divisible by 8 as the number formed by last three digits, i.e., 784 is divisible by 8.

8) **Divisibility by 9** A number is divisible by 9 if the sum of its digits is divisible by 9.
For example, the number 19044 is divisible by 9 as the sum of its digits 1+9 + 0 + 4 + 4- 18 is divisible by 9.

9) **Divisibility by 10** A number is divisible by 10, if it ends in zero.
For example, the last digit of 580 is zero, therefore, 580 is divisible by 10.

10) **Divisibility by 11** A number is divisible by 11 if the difference of the sum of the digits at odd places and sum of the digits at even places is either zero or divisible by 11.
For example, in the number 38797, the sum of the digits at odd places is 3 + 7 + 7 = 17 and the sum of the digits at even places is 8 + 9 = 17. The difference is 17 - 17 = 0, so the number is divisible by 11.

Multiple Choice Questions

In each of the following questions a number of possible answers are given, out of which one answer correct. Find out the correct answer.

1) **$7372 \times 7372 + 7372 \times 628 = ?$**
(a) 58976000 (b) 58967000
(c) 5897600 (d) None of these
Answer: (a)

2) **$9999 + 8888 + 777 + ? = 19700$**
(a) 36 (b) 16
(c) 64 (d) 26
Answer: (a)

3) **60 ? 6 × 111= 666666**
(a) 0 (c) 1
(b) 2 (d) 6
Answer: (a)

4) **3149| × 1? 5 - 425115**
(a) 3 (c) 4
(b) 2 (d) 6
Answer: (a)

5) **If in a long division sum, the dividend is 380606 and the successive remainders from the first to the last are 434, 125 and 413, then divisor is**
(a) 451 (c) 4215
(b) 843 (d) 3372
Answer: (b)

Basic Mathematical
MCQs

1) **The solution of the equation $-3x + 7 = 4x - 12$ falls between what 2 numbers?**
(a) 3 and 3.5 (b) 1 and 2.5
(c) 2.1 and 3 (d) 4 and 4.5
(c) 19 and 7
Answer: (c)

2) **$35x^2 - 11x - 6$ is the product of $5x - 3$ and**
(a) $x - 2$ (b) $7x - 2$
(c) $7x - 6$ (d) $7x$
(e) $7x + 2$
Answer: (e)

3) **For all real numbers x, y and z, $^3\sqrt{(64 x^3 y z^2)} =$**
(a) $8 x y^{1/3} z^{2/3}$ (b) $8 x y^{1/3} z$
(c) $4 x y^{1/3} z^{1/3}$ (d) $4 x y^{1/3} z^{2/3}$
(e) $4 x y^{1/3} z$
Answer: (d)

4) **For all x, $45 x^4 - 115 x^3 - 60 x^2 =$**
(a) $45 x^2(x + 4)(x - 3)$ (b) $5 x^2(9x + 4)(x - 3)$
(c) $5 x^2(9x - 4)(x + 3)$ (d) $5 x^2(9x - 4)(x - 3)$
(e) $45 x^2(x - 4)(x + 3)$
Answer: (b)

5) **Which of the following is one of the factors of the polynomial $-3x^2 - 7x + 26$?**
(a) $x + 2$ (b) $x + 1$
(c) $-3x + 7$ (d) $x - 2$
(e) $3x - 2$
Answer: (d)

6) **What is the product of the solutions of the equation $2x^2 + x - 15$?**
(a) -15/2 (b) 15/2
(c) 15 (d) -15
(e) 2/15
Answer: (a)

7) **If $y = |x - 3|$, what is the value of y^2 when $x = -2$?**
(a) -5 (b) 5
(c) 25 (d) -25
(e) 10
Answer: (c)

8) **The operation ||| is defined by x ||| y = x + y + xy. If -5 ||| y = -13, then y =**
(a) 0 (b) 2
(c) -2 (d) 5
(e) 0
Answer: (b)

9) **A car uses 15 gallons of petrol to travel 300 miles. How many gallons are needed for this car to travel a distance of 430 miles?**
(a) 21.5 (b) 22
(c) 22.5 (d) 23
(e) 23.5
Answer: (a)

10) **Danish has 200 books in his library. 30% of these books are about science. Of these books about science, 20% are about mathematics. How many math books does Danish have?**
(a) 100 (b) 60
(c) 40 (d) 50
(e) 12
Answer: (e)

11) $\sqrt{32}\ \sqrt{2}$
(a) 64 (b) 16
(c) 8 (d) 32
(e) 4
Answer: (c)

12) **If a = 3 and b = -1, then $-3a^2 - 2ab + b^3$**
(a) -30 (b) 32
(c) 34 (d) -34
(e) -22
Answer: (e)

13) $(-3x^2 - x - 10) - (-3x + 8)$?
(a) $-3x^2 - 4x - 2$ (b) $-3x^2 + 2x - 18$
(c) $-6x^2 + 8x - 10$ (d) $-3x^2 - 4x - 18$
(e) $-3x^2 + 4x - 18$
Answer: (b)

14) $(4 - \sqrt{5})(4 + \sqrt{5}) =$
(a) -1 (b) 1
(c) 9 (d) -9
(e) 20
Answer: (a)

15) **In a standard (x,y) coordinate plane, the point (-2 , -6) is located**
(a) in quadrant I (b) on the x axis
(c) in quadrant II (d) in quadrant III
(e) in quadrant IV
Answer: (d)

16) $|-7 - 9| =$
(a) -2 (b) -16
(c) 2 (d) 63
(e) 16
Answer: (e)

17) **If the ratio of 7 to x is equal to 42/30, then x =**
(a) 5 (b) 6
(c) 7 (d) 8
(e) 9
Answer: (a)

$\frac{7}{x} = \frac{42}{30}$

18) **If x = 1/3, then $4x^2 - 2x + 2 =$**
(a) 8/3 (b) 16/9
(c) 4/3 (d) 4
(e) 17/9
Answer: (b)

19) **Which equations corresponds to a line that is perpendicular to the line 2y + 3x = 6**
(a) y = -(2/3)x + 9 (b) y = (3/2)x + 4
(c) y = -(3/2)x – 5 (d) y = 2/3
(e) y = (2/3)x + 3
Answer: (e)

20) $(\sqrt{128}) / 2 + (5\sqrt{2}) / 4 =$
(a) $(\sqrt{130}) / 2$ (b) $(21\sqrt{2}) / 4$
(c) $(133\sqrt{2}) / 4$ (d) $(138\sqrt{2}) / 4$
(e) $(138\sqrt{2}) / 6$
Answer: (b)

21) **Simplify** $\frac{\sqrt{6}+\sqrt{3}}{\sqrt{6}-\sqrt{3}}$
(a) $3+\sqrt{3}$ (b) $3-2\sqrt{3}$
(c) 3 (d) $3+2\sqrt{2}$
Answer: (d)

22) **Find the solution set of** $4 + \left|3 - \frac{x}{3}\right| \geq 9$
(a) $\{x / x \leq -6 \text{ or } x \geq 24\}$ (b) $\{x / x \leq -6 \text{ or } x \geq -24\}$
(c) $\{x / x \geq -6 \text{ or } x \leq 24\}$ (d) $\{x / -6 \leq x \leq 24\}$
Answer: (a)

23) **P is directly proportional to V and P = 100 when V = 4. Find the constant of proportionality and the equation of variation and Use them to find V when P = 50.**
(a) 50 (b) 4
(c) 2 (d) 100
Answer: (c)

24) **To get an A in Biology, you must have a mean of 90 on five tests. Your scores thus far are 83, 93, 88 and 91. How many points must you have on the final test to receive an A?**
(a) 90 points (b) 95 points
(c) 98 points (d) 100 points
Answer: (b)

25) **Last year Saleem was 140cm tall. His height increased by 20 %. How tall is he this year?**
(a) 112 cm (b) 28 cm
(c) 168 cm (d) 141 cm
Answer: (c)

26) **Multiply 0.06 by 0.021**
(a) 0.0126 (b) 0.0000126
(c) 0.00126 (d) 0.126
(e) None of these
Answer: (c)

27) **Divide 4.2 by 0.07**
(a) 1.33 (b) 60
(c) 6 (d) 600
(e) None of these
Answer: (b)

28) **How many fifths are there in 4.8?**
(a) 24 (b) 0.96
(c) 1.04 (d) 9.6
(e) None of these
Answer: (a)

29) **$9 - 3\ (2+6) \div 6 - 2 \times 5$**
(a) -2 (b) 35
(c) 5 (d) -5
(e) None of these
Answer: (d)

30) **The decimal equivalent of $\frac{9}{4}$ is:**
(a) 4.44 (b) 2.25
(c) 0.225 (d) 0.0225
(e) None of these
Answer: (c)

31) **24 is what percent of 40?**
(a) 60% (b) 3.75%
(c) 6% (d) 37.5%
(e) None of these
Answer: (a)

32) **0.85 is 25% of what sum?**
(a) 3.4 (b) 34
(c) 21.25 (d) 2.125
(e) None of these
Answer: (a)

33) **36 is what percent of 30?**
(a) 83.3% (b) 90%
(c) 120% (d) 72%
(e) None of these
Answer: (c)

34) **6 is 15% of what number?**
(a) 90 (b) 0.9
(c) 2.5 (d) 40
(e) None of these
Answer: (d)

35) **The population of a town was 4500 in 1990. In 1994, it had decreased to 3600. Find the percent decrease in population during those four years.**
(a) 80% (b) 90%
(c) 16.2% (d) 20%
(e) None of these
Answer: (d)

36) **You receive a grade of 75% on a test of 60 questions. How many questions did you answer correctly?**
(a) 45 (b) 8
(c) 12 (d) 50
(e) None of these
Answer: (a)

37) **Saleem's monthly salary is Rs 3200. If a deduction for taxes from her monthly paycheck is Rs 800, what percent of her salary goes to these deductions?**
(a) 25% (b) 25.6%
(c) 40% (d) 4%
(e) None of these
Answer: (a)

38) **The cost of an article including 15% for taxes is Rs 138.00. What is the cost of the article without taxes?**
(a) Rs 120.00 (b) Rs 117.30
(c) Rs 20.70 (d) Rs 92.00
(e) None of these
Answer: (a)

39) **The average of the following group of numbers 43, 29, 51, 36, 33, 42, 32 is**
(a) 36 (b) 33
(c) 38 (d) 43
(e) None of these
Answer: (c)

40) **Basit had marks of 80, 94, 70, 68, and 83 on five tests. His average score is between**
(a) 65 and 70 (b) 70 and 75
(c) 75 and 80 (d) 80 and 85
(e) None of these
Answer: (c)

41) **6.42×10^4 is equivalent to:**
(a) 64,200 (b) 642
(c) 0.000642 (d) 642,000
(e) None of these
Answer: (a)

42 **31.7 + 6 + 2.81 + 0.254**
(a) 35.264 (b) 858
(c) 14.52 (d) 40.764
(e) None of these
Answer: (d)

43) **Subtract 5.485 from 12**
(a) -17.485 (b) 17.485
(c) -6.515 (d) 6.515
(e) None of these
Answer: (d)

44) **It takes a bus 3 hours to travel from Lahore to Sahiwal. If the bus averages 88 km/hr, how far is it to Lahore to Sahiwal?**

(a) 286000 m (b) 2.86
(c) 27 km (d) 286 cm
(e) None of these

Answer: (a)

45 **Find the missing term: = -**

(a) 49 (b) 16
(c) 56 (d) 42
(e) None of these

Answer: (a)

46) **$4 \div 2\,[6-(-5)3]=$**

(a) -14 (b)-54
(c) 126 (d) 46
(e) None of these

Answer: (d)

Geometry

1) **Find the measure of an angle which is complement of itself.**

(a) 45 (b) 36
(c) 42 (d) 35

Answer: (a)

2) **An angle is equal to five times its supplement. Find its measure.**

(a) 110 (b) 140
(c) 150 (d) 100

Answer: (c)

3) **The supplement of an angle is one-fourth of itself. Determine the angle and its supplement.**

(a) 132, 48 (b) 156, 24
(c) 118, 62 (d) 144, 36

Answer: (d)

4) **Two complementary angles differ by 18, Find the angles.**

(a) 42, 60 (b) 36, 54
(c) 24, 66 (d) 18, 7 2

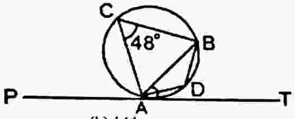
Answer: (b)

5) **If two supplementary angles are In the ratio 1 : 5. Find the difference of the angles.**

(a) 64 (b) 90
(c) 36 (d) 70

Answer: (b)

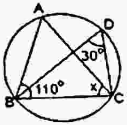
6) **In the given figure, find DADB**



(a) 132 (b) 144
(c) 48 (d) 96

Answer: (a)

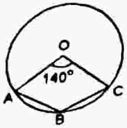
7) **In the following figure, find x**



(a) 40 (b) 25
(c) 30 (d) 45

Answer: (a)

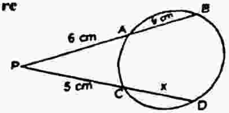
8) In the following figure, it is given that 0 is the center of circle and DAOC= 140, Find D ABC



(a) 110
(b) 120
(c) 115
(d) 130

Answer: (a)

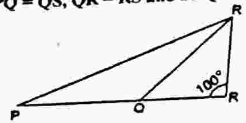
9) **Find x in the given figure**



(a) 13 cm
(b) 12 cm
(c) 16 cm
(d) 15 cm

Answer: (a)

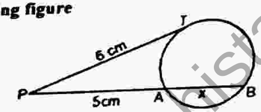
10) **In the figure below, PQ = QS, QR = RS and SRQ = 100° . Find DQPS**



(a) 20
(b) 40
(c) 15
(d) 735

Answer: (a)

11) **Find x in the adjoining figure**



(a) 1.6 cm
(b) 2.2 cm
(c) 3 cm
(a) 2.6 cm

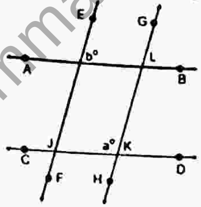
Answer: (b)

12) **In the given figure, AB, CD, EF are concurrent straight lines which pass through O. If D AOE = 90° and x : y = 21, find D DOB and O COF.**

(a) 50, 100
(b) 30°, 60°
(c) 45, 90
(d) 25, 50

Answer: (b)

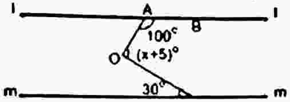
13) **In the given figure, AB || CD and EF || GH. Find the relation between a and b.**



(a) 2a + b=180
(b) a + b = 180
(c) a - b = 180
(d) a + 2b = 180

Answer: (b)

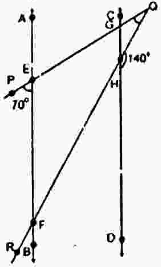
14) **In the given figure, if I 11 m, find the value of x in degree.**



(a) 105
(b) 100°
(c) 110
(d) 115°

Answer: (a)

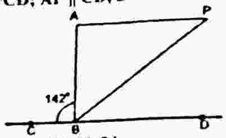
15) **In the given figure, AB 11 CD and they cut PQ and QR at E, F and G, H respectively. D PEB = 70° and D QHD =140° and D PQR = x. Find the value of x in degree.**



(a) 20
(b) 30
(c) 24
(d) 32

Answer: (b)

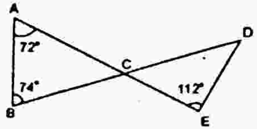
16) **In the given figure, AB ^CD; AP || CD, D CBP = 142° Find D ABP and DAPB.**



(a) 52, 38 (b) 56, 34
(c) 51, 39 (d) 57, 33

Answer: (a)

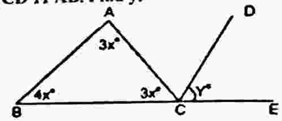
17) **In the figure, D CAB = 72°, DCBA = 74° and D CED = 112° Find D CDE.**



(a) 34 (b) 33
(c) 35 (d) 38

Answer: (a)

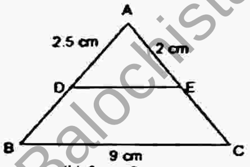
18) **In the given figure, CD 11 AB. Find y.**



(a) 79 (b) 72
(c) 74 (d) 77

Answer: (b)

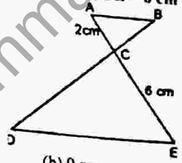
19) **In D ABC, DE || BC, AD = 2.5 cm, DB = 5 cm, AE = 2 cm and BC = 9 cm. Find EC and DE. A 2.5 cm 2 cm**



(a) 4 cm, 3 cm (b) 5 cm, 3 cm
(c) 2 cm, 4 cm (d) 4 cm, 5 cm

Answer: (a)

In the figure, AB || DE and AC = 2 cm, CE = 6 cm and DB = 12 cm. Calculate DC.



(a) 6 cm (b) 9 cm
(c) 12 cm (d) 3 cm

Answer: (b)

Percentage
Test 1

1) **The price of sugar increases by 32%. A family reduces its consumption so that the expenditure of the sugar is up by 10% only. If the total consumption of sugar before the price rise was 10 kg per month, then the consumption of sugar per month at present (in kg) is**

(a) 8.33 (b) 8.5
(c) 8.75 (d) 9

2) **A ball pen factory decided to reduce its production by 10% over that of previous month for next 3 months starting from February 1994. In January 1994, it produced 3000 ball pens. How many ball pens were produced in March 1994?**

(a) 2700 (b) 2430
(c) 2187 (d) 2400

3) **A building worth Rs 133,100 is constructed on land worth Rs. 72,900. After how many years will the value of both be the same if land appreciates at 10% pa. and building depreciates at 10% p.a. ?**

(a) 2.5 (b) 2
(c) 1.5 (d) 3

4) **A man's basic pay for a 40 hour week is Rs. 2000. Overtime is paid for at 25% above the basic rate. In a certain week, he worked overtime and his total wage was Rs. 2500. He, therefore, worked for a total of:**

(a) 45 hours (b) 47 hours
(c) 48 hours (d) 50 hours

5) **Salaries of A, B and C are in the ratio 1:2:3. Salary of B and C together is Rs. 60000. By what percent is salary of C more than that of A?**

(a) 300 (b) 600
(c) 100 (d) 200

6) **The price of a table is Rs. 400 more than that of a chair. If 6 tables and 6 chairs together cost Rs. 4800, by what percent is the price of the chair less than that of the table?**

(a) 200 (b) 400
(c) 100 (d) None of these

7) **The length and breadth of a square are increased by 40% and 30% respectively. The area of the resulting rectangle exceeds the area of the square by?**

(a) 42% (b) 62%
(c) 82% (d) None of these

8) **The length of a rectangle is increased by 20% and the width is decreased by 20%. The area decreases by**

(a) 0.8% (b) 1.2%
(c) 4% (d) 8%

9) **The length of a rectangle is increased by 60%. By what percent would the width have to be decreased to maintain the same area?**

(a) 37 % (b) 60%
(c) 75% (d) None of these

10) **In a market survey, 20% opted for product A whereas 60% opted for product B. The remaining individuals were not certain. If the difference between those who opted for product B and those who were uncertain was 720, how many individuals were covered in the survey?**

(a) 3600 (b) 1440
(c) 1800 (d) Data inadequate

Answers

1	*a*	2	*c*	3	*d*	4	*c*	5	*d*
6	*d*	7	*c*	8	*c*	9	*a*	10	*c*

Percentage

Test 2

1) **5 out of 2250 parts of earth is sulphur. What is the percentage of sulphur in earth?**

(a) 11/50 (b) 2/9
(c) 1/45 (d) 2/45

2) **45 x ? = 25% of 900**

(a) 16.20 (b) 500
(c) 4 (d) 5

3) **218% of 1674 = ? x 1800**

(a) 4 (b) 0.5
(c) 6 (d) None of these

4) **13937.869 ÷ 199.54 + 15% of 201=?**

(a) 150 (b) 90
(c) 80 (d) 100

5) **63% of 25/7 is ?**

(a) 2.25 (b) 2.40
(c) 2.50 (d) 2.75

6) **If 30 % of a number is 12.6, then the number is?**

(a) 41 (b) 51
(c) 52 (d) 42

7) **5% of(25% of Rs. 1600) is?**

(a) Rs. 5 (b) Rs. 17.50
(c) Rs. 20 (d) Rs. 25

8) **(25/3) % of ? = 150**

(a) 1250 (b) 1800
(c) 1700 (d) 1400

9) **35% of 30=25% of ? +1**

(a) 28 (b) 38
(c) 42 (d) 32

10) **?% of 6144 = 5/2 x 245.76**

(a) 16 (b) 20
(c) 5 (d) 10

11) **(30% of 80)/? =24**

(a) 3/10 (b) 3/17
(c) 1 (d) 2

12) **45% of ? + 30% of 90 = 30% of 210.**

(a) 120 (b) 80
(c) 60 (d) 90

13) **One fourth of one third of two fifth of a number is 15. What will be 40% of that number?**

(a) 120 (b) 350
(c) 270 (d) 180

14) **If 37% of a number is 990.86, what will be approximately 19% of that number?**

(a) 600 (b) 400
(c) 500 (d) 700

15) **If 15% of 40 is greater than 25% of a number by 2, the number is ?**

(a) 16 (b) 20
(c) 24 (d) 32

16) **What will be 160% of a number whose 200% is 140?**

(a) 200 (b) 160
(c) 140 (d) 112

17) **If 75% of a number is added to 75, the result is the number itself. Then, the number is ?**

(a) 400 (b) 300
(c) 60 (d) 50

18) **Subtracting 40% of a number from the number, we get the result as 30. The number is?**

(a) 28 (b) 50
(c) 52 (d) 70

19) **If three fifth of a number is 40 more than 40% of the same number. What is the number?**

(a) 100 (b) 150
(c) 200 (d) 400

20) **A number, on subtracting 15 from it, reduces to its 80%. What is 40% of that number?**

(a) 60 (b) 45
(c) 30 (d) 90

Answers

1	*b*	2	*d*	3	*d*	4	*d*	5	*a*
6	*d*	7	*c*	8	*b*	9	*b*	10	*d*
11	*c*	12	*b*	13	*d*	14	*c*	15	*a*
16	*d*	17	*b*	18	*b*	19	*c*	20	*c*

Percentage

Test 3

1) **The population of a town has increased from 133575 to 138918. The percent increase in population is?**
(a) 2.5 (b) 3
(c) 3.5 (d) 4

2) **If x% of y is the same as 4/5 of 80, then the value of xy is**
(a) 320 (b) 400
(c) 640 (d) None

3) **Subtracting 6% of x from xi s equivalent to multiplying x by how much?**
(a) 0 .94 (b) 9.4
(c) 0.094 (d) 94

4) **If 8% of x=4% of y, then 20% of x is?**
(a) 10% of y (b) 16% of y
(c) 80% of y (d) None of these

5) **(x % of y+ y % of x) is?**
(a) x % of y (b) y% of x
(c) 2 % of xy (d) xy % of 3

6) **It is known that 20% of the mangoes are rotten. If number of rotten mangoes is 35, then the total number of mangoes is**
(a) 150 (b) 175
(c) 180 (d) 185

7) **A student has to secure 40% marks to pass. He gets 178 marks and fails by 22 marks. The maximum marks are?**
(a) 200 (b) 500
(c) 800 (d) 1000

8) **A house-owner was having his house painted. He was advised that he would require 25 kg of paint. Allowing for 15% wastage and assuming that the paint is available in 2kg cans, what would be the cost of paint purchased, if one can cost Rs. 16?**
(a) Rs. 240 (b) Rs. 180
(c) Rs. 160 (d) Rs. 360

9 **A reduction of 12.5% in the price of a dining table brought down its price to Rs.4375. The original price (in Rs.) of the table was?**
(a) 6000 (b) 5400
(c) 5200 (d) 5000

10) **In a library, 20% books are Urdu, 50% of the remaining are in English and the remaining 9000 are in various other languages. What is the total number of books in English?**
(a) 4000 (b) 3000
(c) 2250 (d) None of these

Ali spends 30% of his income on CNG, ¼ of the remaining on house rent and the balance on food. If he spends Rs. 300 on CNG then what is the expenditure on house rent?
(a) Rs. 525 (b) Rs. 1000
(c) Rs. 675 (d) Rs. 175

The price of jute has been reduced by 20%. If the reduced price is Rs. 800 per quintal, the original price per quintal was?
(a) Rs. 900 (b) Rs. 640
(c) Rs. 960 (d) Rs. 1000

Tariq spends 40% of his salary on food articles and one third of the remaining on transport. If he saves Rs. 450 per month which is half of the balance after spending on food items and transport, what is his monthly salary-?
(a) Rs. 4500 (b) Rs. 2250
(c) Rs. 1125 (d) Rs. 2500

In an examination, 1100 boys and 900 girls appeared. 50% of the boys and 40% of the girls passed the examination. The percentage of candidates failed is?
(a) 45 (b) 45.5
(c) 54.5 (d) 59.2

Haris secured 50% marks in Sindhi, 60% in English and 70% in Math as well as in Science. What were his total marks if the maximum marks obtainable in each of these 4 subjects was 50?
(a) 125 (b) 120
(c) 250 (d) 150

16) **In a city, 35% of the population is composed of migrants, 20% of whom are from rural areas. Of the local population, 48% is female while this figure for rural and urban migrants is 30% and 40% respectively. If the total population of the city is 728400, what is its female population?**
(a) 324138 (b) 349680
(c) 509940 (d) None

17) **A's marks in Biology are 20 less than 25% of the total marks obtained by him in Biology, Maths and Physics. If his marks in Physics be 50, what are his marks in Maths?**
(a) 40 (b) 45
(c) 50 (d) can't be determined

18) **An increase of Rs. 60 in the monthly salary of Umar made it 50% of the monthly salary of Ali. What is Umar's present monthly salary ?**
(a) Rs. 180 (b) Rs. 240
(c) Rs. 300 (d) Data inadequate

19) **A man bought a house for Rs. 5 lakhs and rents it. He puts 12.5% of each month's rent aside for repairs, pays Rs. 1660 as annual taxes and realizes 10% on his investment thereafter. The monthly rent of the house is?**
(a) Rs. 5000 (b) Rs. 4920
(c) Rs. 2500 (d) Rs. 2460

20) **In a public school, 1/5th of girls and 1/4th of boys are under 12 years of age. If the total strength of the school is 1000 and number of girls is 2/5th of the total, what part of the total strength of the school is accounted for by those which are 12 years or more of age?**

(a) 23% (b) 45%
(c) 55% (d) 77%

Answers

1	*d*	2	*d*	3	*a*	4	*d*	5	*c*
6	*b*	7	*b*	8	*a*	9	*d*	10	*d*
11	*d*	12	*d*	13	*b*	14	*c*	15	*a*
16	*d*	17	*d*	18	*d*	19	*b*	20	*d*

Percentage

Test 4

1) **A debtor can pay 87 Paisa's in the rupee, but if his creditors would take 20% of his debts, he could pay them and have Rs. 42 left. His debts and assets respectively are?**

(a) Rs. 600, Rs. 522 (b) Rs. 500 , Rs. 521
(c) Rs. 400, Rs. 520 (d) Rs. 1000, Rs. 525

2) **300 grams of sugar solution has 40% sugar in it. How much sugar should be added to make it 50% in the solution?**

(a) 10 gms (b) 40 gms
(c) 60 gms (d) 80 gms

3) **The price of an article is cut by 20%. To restore it to the former value, the new price must be increased by?**

(a) 20% (b) 25 %
(c) 16 (d) 24%

4) **In an examination, there are 3 papers of Mathematics of 100 marks each. A boy secures 60% in the first paper and 70% in the second paper. In order to secure 70% in the aggregate the percentage of marks he should secure in third paper will be?**

(a) 90% (b) 80%
(c) 75% (d) 70%

5) **5% of income of A is equal to 15% of income of B and 10% of income of B is equal to 20% of income of C. If income of C is Rs. 2000, then total income of A, B & C is?**

(a) Rs. 6000 (b) Rs. 18000
(c) Rs. 20000 (d) Rs. 14000

6) **In an examination, A got 10% marks less than B, B got 25% marks more than C and C got 20% less than D. If A got 360 marks out of 500, the percentage of marks obtained by D was?**

(a) 70 (b) 75
(c) 80 (d) 85

7) **In an examination, 80% of the students passed in English, 85% in Mathematics and 75% in both English and Mathematics. If 40 students failed in both the subjects, the total number of students is**

(a) 200 (b) 400
(c) 600 (d) 800

In an examination, 35% candidates failed in one subject and 42% failed in another subject while 15% failed in both the subjects. If 2500 candidates appeared at the examination, how many passed in either subject but not in both?

(a) 325 (b) 1175
(c) 2125 (d) None of these

In an election between two candidates, one got 55% of total valid votes. 20% of the votes were invalid. If the total number of votes was 7500, the number of valid votes that the other candidate got was

(a) 2700 (b) 2900
(c) 3000 (d) 3100

At an election involving two candidates, 68 votes were declared invalid. The winning candidate scores 52% and wins by 98 votes. The total number of votes polled is ?

(a) 2518 (b) 2450
(c) 2382 (d) None of these

11) **A's income is 25% more than B's income. B income in terms of A's income is?**

(a) 75% (b) 80 %.
(c) 90% (d) 96%

12) **Water tax is increased by 20% but its consumption is decreased by 20%. Then, the increase or decrease in the expenditure of the money is**

(a) No change (b) 5% decrease
(c) 4% increase (d) 4% decrease

13) **On increasing the price of T.V. sets by 30%, their sale decreases by 20%. What is the effect on the revenue receipts of the shop?**

(a) 4% increase (b) 4% decrease
(c) 8% increase (d) 8% decrease

14) **The price of sugar increases by 20%. By what percent must a house wife reduce the consumption of sugar, so that the expenditure on sugar is the same as before ?**

(a) 16.66 (b) 20
(c) 80 (d) 83.33

15) **The price of sugar is increased by 20%. As a result, a family decreases its consumption by 25%. The expenditure of the family on sugar will be decreased by**

(a) 10% (b) 5%
(c) 14% (d) 15%

Answers

1	*a*	2	*c*	3	*b*	4	*b*	5	*b*
6	*c*	7	*b*	8	*b*	9	*a*	10	*a*
11	*b*	12	*d*	13	*a*	14	*a*	15	*a*

Quantitative Questions

1) **What could be the maximum value of a in the following equation.**
5B9 + 3C7 + 2A8 = 1114
(a).9 (b).0
(c).1 (d).8

Answer: (a)

2) **find the unit's digit in the sum**
$(264)^{102} + (264)^{103}$
(a).1 (b).0
(c).2 (d).3

Answer: (b)

3) **What is the least value must be assigned to * so that the number 12345*68 is divisible by 9.**
(a).6 (b).7
(c).8 (d).9

Answer: (b)

4) **If the largest 4 digit number is subtracted from the smallest 6 digit number then the remainder is.**
(a).90001 (b).9001
(c).901 (d).900001

Answer: (a)

5) **What will come in place of question mark. 597 x 999 =?**
(a).589413 (b).588413
(c).587413 (d).596403

Answer: (d)

6) **The product of the following is. 12345679 x 72**
(a).888888988 (b).88889888
(c).888888888 (d).988888888

Answer: (c)

7) **A positive integer, which when added to 1000 gives a sum which is greater then when it is multiplied by 1000.this positive integer is.**
(a).1 (b).2
(c).3 (d).4

Answer: (a)

8) **The smallest 3 digit prime number is.**
(a).101 (b).103
(c).107 (d).None of these

Answer: (a)

9) **The sum of three prime numbers is 100. if one of them exceeds another by 36,then one of the numbers is:**
(a).7 (b).29
(c).41 (d).67

Answer: (d)

10) **If 345*68 is divisible by 3 then what will replace *?**
(a).1 (b).2
(c).3 (d).5

Answer: (a)

The greatest number by which the product of three consecutive multiples of 3 is always divisible is: then one of the numbers is:
(a).162 (b).54
(c).81 (d).243

nswer: (a)

The maximum number of students among them 1001 pens and 910 pencils can be distributed in such a way that each student gets the same number of pens and same number of pencils is:
(a).91 (b).910
(c).1001 (d).1911

nswer: (a)

3) **The ratio of two numbers is 3 : 4 and their H.C.F is 4 their L.C.M is: 48 then one of the numbers is:**
(a).12 (b).48
(c).24 (d).16

nswer: (b)

4) **The product of two numbers is 4107. if the H.C.F of these numbers is 37 then the greater number is: then one of the numbers is:**
(a).101 (b) 111
(c).107 (d).122

Answer: (b)

15) **Three numbers are co-primes to each other are such that the product of the first two is 551 and that of the last two is 1073 then sum of these three numbers is:**
(a).75 (b).85
(c).95 (d).105

Answer: (b)

16) **L.C.M of two numbers is 495 and their H.C.F. is 5, if the sum of the numbers is 10, then their difference is:**
(a).10 (b).46
(c).70 (d).90

Answer: (a)

17) **H.C.F of two numbers is 8 which of the following can never be their L.C.M:**
(a).16 (b).24
(c).32 (d).40

Answer: (d)

18) **Two numbers both greater than 29 have H.C.F 29 and L.C.M 4147. The sum of numbers is:**
(a).696 (b).796
(c).596 (d).896

Answer: (a)

19) **Which of the following has fractions in ascending order:**
(a).1/3 , 2/5 , 4/7 , 3/5 , 5/6 , 6/7
(b).1/3 , 2/5 , 3/5 , 4/7 , 5/6 ,6/7
(c).1/3 , 2/5 , 3/5 , 5/6 , 4/7 , 6/7
(d).2/5 , 3/5 , 1/3 , 4/7 , 5/6 , 6/7

Answer: (a)

20) 3 x 0.3 x 0.03 x 0.003 x 30 =?
(a).0.0000243 (b).0.000243
(c).0.00243 (d).0.0243
Answer: (c)

21) The least among the following is:
(a).0.2 (b).1/0.2
(c).0.2222 (d).$(0.2)^2$
Answer: (d)

22) If 1/6.198 = 0.1614 then the value of 1/0.0006198 is:
(a).0.016134 (b).0.16134
(c).1613.4 (d).16134
Answer: (d)

23) If 4/5 of an estate be worth Rs. 16800 then the value of 3/7 of the estate is:
(a).9000 (b).9000
(c).72000 (d).90.000
Answer: (b)

24) 7 is added to a certain number, then the sum is multiplied by 5; then the product is divided by 9 and then 3 is subtracted from the quotient. The remainder left is 12. The number is:
(a).20 (b).30
(c).40 (d).60
Answer: (a)

25) 2.002 + 7.9{2.8 - 6.3(3.6 - 1.5) + 15.6} =?
(a).2.002 (b).4.2845
(c).40.843 (d).42.845
Answer: (d)

26) If (2a+b)/(a+4b) = 3 , then find the value of (a+b)/(a+2b).
(a).2/7 (b).5/9
(c).10/7 (d).10/9
Answer: (d)

27) When a ball bounces, it rises to 3/4 of the height from which it fell. if the ball is dropped from a height of 32 m, how high will it rise at the third bounce?
(a).13 M (b).13.5 M
(c).14.5 M (d).16.5 M
Answer: (b)

28) A person travels 3.5 km from place a to place b. out of this distance he travels 5/3 on bicycle ,7/6 km on scooter and the rest on foot. What portion of the whole distance does he cover on foot?
(a).3/19 (b).4/11
(c).4/21 (d).5/6
Answer: (c)

29) What fraction of 4/7 must be added to itself to make the sum 15/14?
(a).1/2 (b).4/7
(c).7/8 (d).15/14
Answer: (c)

30) A certain number of tennis balls was purchased for Rs 450. Five more balls could have been purchased in the same amount if each ball was cheaper by Rs 15. The number of balls purchased was:
(a).10 (b).15
(c).20 (d).25
Answer: (a)

31) 1/10 of a pole is colored red, 1/20 white, 1/30 blue, 1/40 black, 1/50 violet, 1/60 yellow and the rest is green. if the length of the green portion of the pole is 12.08 meters, then the length of the pole is:
(a).16 m (b).18 m
(c).20 m (d).30 m
Answer: (a)

32) 1/4 of a tank holds 135 liters of water. What part of the tank is full if it contains 180 liters of water?
(a).1/6 (b).1/3
(c).2/3 (d).2/5
Answer: (b)

33) In a classroom if 6 students per bench are assigned to accommodate all students, one more bench will be required. However if 7 students are accommodated per bench there would be a space left for 5 students. What is the number of students in the class?
(a).30 (b).42
(c).72 (d).82
Answer: (c)

34) The average of a non-zero number and its square is 5 times the number. The number is:
(a).9 (b).17
(c).19 (d).295
Answer: (a)

35) The average of 7 consecutive numbers is 20. The largest of these numbers is:
(a).20 (b).22
(c).23 (d).24
Answer: (c)

36) The average of runs of a cricket player of 10 innings was 32. How many runs must he make in his next innings so as to increase his average of runs by 4?
(a).2 (b).4
(c).76 (d).77
Answer: (c)

37) The sum of the number of boys and girls in a school is 150. if the number of boys is r then the number of girls becomes r% of the total number of students. The number of boys is:
(a).40 (b).50
(c).60 (d).90
Answer: (c)

38) **In an examination 35% of the students passed and 455 failed. How many students appeared for the examination?**
(a).490 (b).700
(c).845 (d).1300
Answer: (b)

MCQs on Remainder Theorem

1) **If $x4 - 3x + 5$ is divided by $2x - 1$, then the remainder is**
(a). 35/16 (b). -35/16
(c). −9 (d). 3
Answer: (c)

2) **If $x^2 - 7x + a$ has a remainder 1 when divided by $x + 1$, then**
(a). a = -7 (b). a = 7
(c). a = 0 (d). a = 1
Answer: (a)

3) **If $x^3 + 9x + 5$ is divided by x, then the remainder is**
(a). 9 (b). 0
(c). −9 (d). 5
Answer: (d)

4) **If $x^2 + ax + b$ is divided by $x + c$, then remainder is**
(a). $c^2 - ac - b$ (b). $c^2 - ac + b$
(c). $c^2 + ac + b$ (d). $-c2 - ac + b$
Answer: (a)

5) **If $x^3 + 9x + 5$ is divided by x, then the remainder is**
(a). 9 (b). 0
(c). −9 (d). 5
Answer: (d)

6) **Use the remainder theorem to find the remainder when f(x) is divided by x-k.**
$f(x) = 2x^2 - 3x + 1$; k+2
(a). 15 (b). 9
(c). 18 (d). 3
Answer: (d)

7) **Use the remainder theorem to find the remainder when f(x) is divided by x-k**
$f(x) = x^3 - x^2 + 2x - 1$; k=-3
(a).41 (b).-43
(c).-46 (d).-32
Answer: (b)

8) **What is the remainder of $f(x) = 2x^3 - 3x^2 + 4x - 7$; k=2**
(a).20 (b).2
(c).10 (d).5
Answer: (d)

MCQs on Rounding Off Numbers

1) **Round off value of 10256/32548 up to three decimal places is**
(a) 0.315 (b) 0.316
(c) 0.318 (d) 0.32
Answer: (a)

2) **Round off value of 38.23 to nearest whole number is**
(a) 40 (b) 37
(c) 38 (d) 39
Answer: (c)

3) **Round off value of 108.76 to nearest whole number is**
(a) 106 (b) 109
(c) 108 (d) 107
Answer: (b)

4) **Round off value of 0.7868 to nearest whole number is**
(a) 1.5 (b) 0.5
(c) 1 (d) 2
Answer: (c)

5) **Round off value of 230/105 to nearest whole number is**
(a) 23 (b) 20
(c) 21 (d) 22
Answer: (d)

MCQs/Objective Questions

Addition/Subtraction, Under Root, Squares
Ratio, Interest, Area and Cost, Profit and Loss Fraction, Ages, Probability

1) **$(9^{5.6} x\ 9^{10.3}) \div 9^{2.56}256 = 9^{?}$**
(a) 13.14 (b) 12.96
(c) 12.43 (d) 13.34
(e) None of these

2) **(4 86%of 6500) ÷ 36 =?**
(a) 867.8 (b) 792.31
(c) 877.5 (d) 799.83
(e) None of these

3) **$(12.11)^2 + (?)^2 = 732.2921$**
(a) 20.2 (b) 24.2
(c) 23.1 (d) 19.2
(e) None of these

4) **576÷ ? x114=8208**
(a) 8 (b) 7
(c) 6 (d) 9
(e) None of these

5) **(1024—263—233) ÷ (986—764— 156) =?**
(a) 9 (b) 6
(c) 7 (d) 8
(e) None of these

6) **? 125÷ 5x ?=6265**
(a) 1253 (b) 1250
(c) 1245 (d) 1550
(e) None of these

7) **(42)^2÷6.3 x 26 =?**
(a) 7182 (b) 7269
(c) 7260 (d) 7240
(e) None of these

8) **384x12x2=?**
(a) 9024 (b) 9216
(c) 6676 (d) 6814
(e) None of these

9) **6534÷40÷33=?**
(a) 3.06 (b) 5.25
(c) 4.82 (d) 6.12
(e) None of these

10) **? 2704 x? 2209=?**
(a) 1996 (b) 2444
(c) 2452 (d) 1983
(e) None of these

11) **2536+4851—? = 3450+313**
(a) 3961 (b) 4532
(c) 3624 (d) 4058
(e) None of these

12) **(2560 x 1.4) + (7400 x 0.6) =?**
(a) 7512 (b) 9746
(c) 6523 (d) 8024
(e) None of these

13) **36%of 850+? %of 592 = 750**
(a) 73 (b) 89
(c) 82 (d) 75
(e) None of these

14) **64%of 2650+40% 0f 320=?**
(a) 1824 (b) 1902
(c) 1829 (d) 1964
(e) None of these

15) **486+32×25—59=?**
(a) 514 (b) 528
(c) 599 (d) 507
(e) None of these

16) **1827÷ 36 x ?=162.4**
(a) 4.4 (b) 3.2
(c) 2.1 (d) 3.7
(e) None of these

17) **1008÷36=?**
(a) 28 (b) 32.5
(c) 36 (d) 22.2
(e) None of these

18) **56.21 +2.36+5.41 —21.4+1.5=?**
(a) 40.04 (b) 46.18
(c) 44.08 (d) 43.12
(e) None of these

19) **65%of 320+? = 686**
(a) 480 (b) 452
(c) 461 (d) 475
(e) None of these

20) **83250÷ ?= 74×25**
(a) 50 (b) 45
(c) 40 (d) 55
(e) None of these

21) **?7744=?**
(a) 88 (b) 62
(c) 58 (d) 78
(e)None of these

22) **35% of ?=242**
(a) 729 (b) 652
(c) 693 (d) 759
(e) None of these

23) **1256+4813+765=?**
(a) 5642 (b) 5876
(c) 6788 (d) 6878
(e) None of these

24) **22 x4+ (?)^2= (13)^2**
(a) 81 (c) 27
(b) 9 (d) 64
(e) None of these

25) **432+2170+35=?**
(a) 494 (b) 475
(c) 481 (d) 469
(e) None of these

26) **Three numbers are in the ratio of 3: 4 :5 respectively. If the sum of the first and third numbers is more than the second number by 52, then which will be the largest number?**
(a) 65 (b) 52
(c) 79 (d) 63
(e) None of these

27) **The compound interest on a certain amount for 2 years at the rate of 8 p.c.p.a. is Rs.312. What will be the simple interest on the same amount and at the same rate and same time?**
(a) Rs. 349.92 (b) Rs. 300
(c) Rs. 358.92 (d) Rs. 400
(e) None of these

28) **The length of a rectangle exceeds its breadth by 7 cms. If the length is decreased by 4 cm. and the breadth is increased by 3 cms. Then the area of the new rectangle will be the same as the area of the original rectangle. What will be the perimeter of the original rectangle?**
(a) 45 cms. (b) 40 cems.
(c) 50 cms. (d) 55 cms.
(e)None of these

29) **The sum of the digits of a two digit number is 12. If the new number formed by reversing the digits is greater than the original number by 54, then what will be the original number?**
(a) 28 (b) 48
(c) 39 (d) 93
(e) None of these

30) **In a fraction, twice the numerator is two more than the denominator. If 3 is added to the numerator and the denominator each, then the resultant fraction will be 2/3. What was the original fraction?**
(a) 5/18 (b) 6/13
(c) 13/6 (d) 7/12
(e) None of these

31) **Four-fifth of a number is 10 more than two-third of the same number. What is the number?**
(a) 70 (b) 75
(c) 69 (d) 85
(e) None of these

32) **A shopkeeper purchased 200 bulbs for Rs. 10 each. However, 5 bulbs were fused and had to be thrown away. The remaining were sold at Rs. 12 each. What will be the percentage profit?**
(a) 25 (b) 15
(c) 13 (d) 17
(e) None of these

33) **What should come in the place of question mark (?) in the number series given below?**
25, 34, 52, 79, 115,?
(a) 160 (b) 140
(c) 153 (d) 190
(e)None of these

34) **What number should replace both the question marks (?) in the following question?**
?/144= 49 /?
(a) 95 (b) 76
(c) 82 (d) 84
(e)None of these

35) **The sum of three consecutive even numbers is 252. What is the sum of the smallest and the largest numbers?**
(a) 158 (b) 148
(c) 168 (d) 198
(e) None of these

36) **Asad spends 25% of his salary on house rent, 5% on food, 15% on travel, 10% on clothes and the remaining amount of Rs. 27,000 is saved. What is Asad's income?**
(a) Rs. 60,000 (b) Rs. 80,500
(c) Rs. 60,700 (d) Rs. 70,500
(e) None of these

37) **In how many different ways, can the letters of the word 'CRISIS' be arranged?**
(a) 150 (b) 240
(c) 120 (d) 200
(e) None of these

38) **At each corner of a square park with side equal to 40 m, there is a flower bed in the form of a sector of radius 14 m. What is the area of the remaining part of the park?**
(a) 984 Square m (b) 789 Square m
(c) 1014 Square m (d) 1024 Square m
(e) None of these

39) **The length of a rectangular field is thrice its breadth. If the cost of cultivating the field at Rs. 367.20 per square meter is Rs. 27,540, then what is the perimeter of the rectangle?**
(a) 47m (b) 39m
(c) 52m (d) 40m
(e) None of these

40) **If the fractions8/5,7/2,9/5,5/4,4/5 are arranged in descending order of their values, which one will be fourth?**
(a) 4/5 (b) 5/4
(c) 9/5 (d) 8/5
(e) 7/2

41) **The present ages of Asad and Ali are in the ratio of 5 :7 respectively. After 7 years, their ages will be in the ratio of 11:14 respectively. What is the difference between their ages?**
(a) 9 years (b) 4 years
(c) 5 years (d) 7 years
(e) None of these

42) **If 13 men can complete a piece of work in 36 days, then in how many days will 18 men complete the same work?**
(a) 16 days (b) 20 days
(c) 26 days (d) 30 days
(e) None of these

43) **If the area of a circle is 75.44 square cm then what is the circumference of the circle?**
(a) 29.2 cm (b) 28.9 cm
(c) 30.8 cm (d) 40.2 cm
(e) None of these

44) **Imran started a business investing Rs. 45,000. After 3 months, Asif joined him with a capital of Rs. 60,000. After another 6 months, Waleed joined them with a capital, of Rs. 90,000. At the end of the year, they made a profit of Rs. 16,500. What is Imran's share of profit?**
(a) Rs. 5,500 (b) Rs. 6,000
(c) Rs. 6,600 (d) Rs. 5,900
(e) None of these

45) **What is the average age of a family of five members, whose ages are 42, 49, 56, 63 and 35 years respectively?**
(a) 60 years (b) 49 years
(c) 45 years (d) 58 years
(e) None of these

46) **A and B are two taps which can fill a tank individually in 10 minutes and 20 minutes respectively. However, there is a leakage at the bottom which can empty a filled tank in 40 minutes. If the tank is empty initially, how much time will both the taps take to fill the tank (leakage is still there)?**
(a) 8 minutes (b) 7 minutes
(c) 10 minutes (d)15 minutes
(e) None of these

47) **What is 50% of 40% of Rs. 3,450?**
(a) Rs. 690 (b) As. 520
(c) Rs. 517.5 (d) Rs. 499.2
(e) None of these

48) **If an amount of Rs. 5, 86,700 is distributed equally amongst 25 persons, then how much would each person get?**
(a) Rs. 2, 54,876 (b) Rs. 2, 34, 68
(c) Rs. 3, 74, 20 (d) Rs. 1, 95, 62
(e) None of these

49) **An urn contains 9 blue, 7 white and 4 black balls. If 2 balls are drawn at random, then what is the probability that only one ball is white?**
(a) 71/190 (b) 121/190
(c) 91/190 (d) 93/190
(e) None of these

50) **If the price of 5 transistors and 2 pen stands is Rs. 810, then what will be the price of 7 transistors and 9 pen stands?**
(a) Rs. 1,320 (b) Rs. 1,500
(c) Rs. 1,150 (d) cannot be determined
(e) None of these

Answers

1	d	2	c	3	b	4	a	5	d
6	a	7	e	8	b	9	e	10	b
11	c	12	d	13	d	14	a	15	b
16	b	17	a	18	c	19	e	20	b
21	a	22	c	23	e	24	b	25	a
26	a	27	b	28	c	29	c	30	d
31	b	32	d	33	a	34	d	35	e
36	a	37	e	38	a	39	d	40	b
41	e	42	c	43	c	44	a	45	b
46	a	47	a	48	b	49	e	50	d

Alphabet Series

ach of the following questions, various terms of an alphabet series are given with one or more missing as shown by (?). Choose the missing terms out of the given alternatives.

AZ, CX, FU,?
(a).IR (b).IV (c).JQ (d).KP
Answer: (c)

AZ, BY, CX, ?
(a).EF (b).GH (c).IJ (d).DW
Answer: (d)

DKY, FJW, HIU, JHS, ?
(a).KGR (b).LFQ (c).KFR (d).LGQ
Answer: (d)

?, SIY, OEU, KAQ, GWM, CSI
(a).WNE (b).WNB (c).WNE (d).WMC
Answer: (d)

CMW, HRB, ?, RBL, WGQ, BLV
(a).MWG (b).LVF (c).LWG (d).WMX
Answer: (a)

6) **BXJ, ETL, HPN, KLP, ?**
(a).NHR (b).MHQ (c).MIP (d).NIR
Answer: (a)

7) **QPO, SRQ, UTS, WVU, ?**
(a).XVZ (b). ZYA (c). YXW (d). VWX
Answer: (c)

8) **JE, LH, OL, SQ, ?**
(a).WV (b). WX (c). VW (d). XW
Answer: (d)

9) **AD, EH, IL, ?, QT**
(a).LM (b). MN (c). MP (d). OM
Answer: (c)

Choose the missing terms out of the given alternatives.

10) **BMO, EOQ, HQS, ?**
(a).KSU (b). LMN (c). SOV (d). SOW
Answer: (a)

11) **AC, FH, KM, PR, ?**
(a). UW (b). VW (c). UX (d). TV
Answer: (a)

12) **T, R, P, N, L, ?, ?**
(a). J, G (b). J, H (c). K, H (d). K, I
Answer: (b)

13) **R, U, X, A, D, ?**
(a). F (b). G (c). H (d). I
Answer: (b)

14) **B, E, D, F, ?, H, J, ?, L**
(a).I, M (b).M, I (c).I, N (d).J, M
Answer: (a)

15) **M, N, O, L, R, I, V, ?**
(a).A (b).E (c).F (d).H

Answer: (b)

Coding—Decoding Test

1) **If KEDGY is coded as EKDYG then how will LIGHT be coded?**
(a) ILHTG (b) ILGHT (c) ILGTH (d) THGIL
(e) None of these

Answer: (c)

2) **If RAVE is coded as SXWB then how will SCAW be coded?**
(a) TDBO (b) TZBK (c) PZXK (d) TVXK
(e) None of these

Answer: (b)

3) **If SPANK is coded as PSNAK then how will THROW be coded?**
(a) HTORW (b) HTWOR (c) HTWRO (d) HTRWO
(e) None of these

Answer: (a)

4) **If UDOMETER is coded as DUMOTERE then how will SUBLEASE be coded?**
(a) USLBESAE (b) USLBAEES
(c) USBAELES (d) USLBEAES
(e) None of these

Answer: (b)

5) **If PURSER is coded as UPSRRE then how will PERIODIC be coded?**
(a) EPRIDOIC (b) PEIRDOCI
(c) EPIRDOCI (d) EPIRODCI
(e) None of these

Answer: (c)

6) **If STRAY is coded as TUSBZ then how will MOURN be coded?**
(a) LPVSO (b) NPVSO
(c) NVPSO (d) NPSVO
(e) None of these

Answer: (b)

7) **If MAGIC is coded as PXJFF then how will LEASH be coded?**
(a) PBDVD (b) OBDVL
(c) OHEOK (d) OBDPK
(e) None of these

Answer: (d)

8) **If DOWN is coded as FQYP then how will WITH be coded?**
(a) KYN (b) JYK
(c) YKVJ (d) JKVY
(e) None of these

Answer: (c)

9) **If BINARY is coded as DHPZTK then how will KIDNAP be coded?**
(a) MKFPCQ (b) MHFPZQ
(c) IKFMYO (d) MHFMCO
(e) None of these

Answer: (d)

10) **If RASCAL is coded as QZRBZK then how will SOLDER be coded?**
(a) RNMEDQ (b) RPKEDS
(c) TPMEFS (d) RNKCDQ
(e) None of these

Answer: (d)

11) **If SAVOURY is coded as OVUARSY then how will RADIATE be coded?**
(a) AIDARET (b) IDARATE
(c) ARIADTE (d) IDAATRE
(e) None of these

Answer: (d)

12) **If MAPLE is coded as VOKZN then how will CAMEL be coded?**
(a) OVNZF (b) OUNZX
(c) OVNZX (d) XZNVO
(e) None of these

Answer: (c)

13) **If CRY is coded as MRYC then how will GET be coded?**
(a) MTEG (b) MGET
(c) MEGT (d) METG
(e) None of these

Answer: (d)

14) **If BURNER is coded as CASOIS then how will ALIMENT be coded?**
(a) BKJLFMU (b) EKOLIMS
(c) EMONIOU (d) BRJSFTU
(e) EROSITU

Answer: (c)

15) **If Sand is coded as Brick, Brick as House, House as Mosque, Mosque as Palace then where do you worship?**
(a) Palace (b) Mosque
(c) Brick (d) House
(e) None of these

Answer: (a)

16) **If Rajdoot is coded as Car, Car as Aero plane, Aero plane as Train, Train as Bus, then by which vehicle can you reach your destination in least time? .**
(a) Aero plane (b) Train (c) Car (d) Bus (e) None of these

Answer: (b)

17) **If Pen is coded as Pencil, Pencil as Chalk, Chalk as Slate, Slate as Paper, then by which do you mostly write?**
(a) Pen (b) Pencil (c) Chalk (d) Slate (e) None of these

Answer: (b)

18) **If Leader is coded as Actor, Actor as an Administrator, Administrator as a Traitor, Traitor as a Social-reformer, then who takes part in the Parliamentary elections?**
(a) Administrator (b) Leader
(c) Traitor (d) Social-Reformist
(e) None of these

Answer: (e)

19) If '245' means—'Art and Talent' in a certain code language, '316' means— 'Callous to Generous', '147' means— 'Callous and Polite' then what is the code used for 'to' ?
(a) Only 3 (b) Only 1 (c) 3 or 6 (d) Only 6
(e) None of these

Answer: (c)

20) In a certain code language '579' means—'Kanchan is soft-spoken', '694' means—'Soft-spoken beautiful pure', '473' means—'Pak is pure', then what is the code used for 'Kanchan'?
(a) 7 (b) 5 (c) 9 (e) None of these

Answer: (b)

21) If 'MLT' means—'Day is clear', 'LKS' means—'Life is sad', 'SMMO' means—'Clear or sad', then what is the code used for 'Day'?
(a) T (b) K (c) MO (d) L
(e) None of these

Answer: (a) –

Blood Relation Test

1) **Pointing to a photograph of a boy Faizan said, "He is the son of the only son of my mother." How is Faizan related to that boy?**
(a).Brother (b).Uncle (c).Cousin
(d).Father

Answer: (d)

2) **If A + B means A is the mother of B; A - B means A is the brother B; A % B means A is the father of B and A x B means A is the sister of B, which of the following shows that P is the maternal uncle of Q?**
(a).Q - N + M x P (b).P + S x N – Q
(c).P - M + N x Q (d).Q - S % P

Answer: (c)

3) **If A is the brother of B; B is the sister of C; and C is the father of D, how D is related to A?**
(a).Brother (b).Sister
(c).Nephew (d).Cannot be determined

Answer: (d)

4) **If A + B means A is the brother of B; A - B means A is the sister of B and A x B means A is the father of B. Which of the following means that C is the son of M?**
(a).M - N x C + F (b).F - C + N x M
(c).N + M - F x C (d).M x N - C + F

Answer: (d)

5) **Introducing a boy, a girl said, "He is the son of the daughter of the father of my uncle." How is the boy related to the girl?**
(a).Brother (b).Nephew (c).Uncle (d).Son-in-law

Answer: (a)

6) **Pointing to a photograph Usman says, "He is the son of the only son of my grandfather." How is the man in the photograph related to Usman?**
(a).Brother (b).Uncle (c).Cousin (d).Data is inadequate

Answer: (a)

7) **If A + B means A is the brother of B; A x B means A is the son of B; and A % B means B is the daughter of A then which of the following means M is the maternal uncle of N?**
(a).M + O x N (b).M % O x N + P
(c).M + O % N (d).None of these

Answer: (d)

8) **If D is the brother of B, how B is related to C? To answer this question which of the statements is/are necessary?**
The son of D is the grandson of C.
B is the sister of D.
(a).Only 1 (b).Only 2
(c).Either 1 or 2 (d).1 and 2 both are required

Answer: (d)

9) **If A + B means A is the father of B; A - B means A is the brother B; A % B means A is the wife of B and A x B means A is the mother of B, which of the following shows that M is the maternal grandmother of T?**
(a).M x N % S + T (b).M x N - S % T
(c).M x S - N % T (d).M x N x S % T

Answer: (a)

10) **Osama said to Ayesha, "That boy playing with the football is the younger of the two brothers of the daughter of my father's wife." How is the boy playing football related to Osama?**
(a).Son (b).Brother (c).Cousin (d).Brother-in-law

Answer: (b)

11) **Zoya who is the sister-in-law of Kashif , is the daughter-in-law of Raheela. Rehman is the father of Imran who is the only brother of Kashif. How Raheela is related to Kashif?**
(a).Mother-in-law (b).Aunt
(c).Wife (d).None of these

Answer: (d)

12) **Pointing to a woman, Zeeshan said, "Her granddaughter is the only daughter of my brother." How is the woman related to Zeeshan?**
(a).Sister (b).Grandmother (c).Mother-in-law (d).Mother

Answer: (d)

13) **Farhan said - "This girl is the wife of the grandson of my mother". How is Farhan related to the girl?**
(a).Brother (b).Grandfather (c).Husband (d).Father-in-law

Answer: *(d)*

14) **A and B are children of D. Who is the father of A? To answer this question which of the statements (1) and (2) is necessary?**
C is the brother of A and the son of E.
F is the mother B.
(a).Only (1) (b).Only (2)
(c).Either (1) or (2) (d).(1) and (2) both

Answer: (b)

15) **Pointing towards a man, a woman said. "His mother is the only daughter of my mother." How is the woman related to the man?**
(a) Mother (b) Grandmother
(c) Sister (d) Daughter
Answer: (a)

Logical Reasoning

1) **Look at this series: 2, 1, (1/2), (1/4), ...** What number should come next?
Answer: 1/8
2) **Look at this series: 7, 10, 8, 11, 9, 12, ...** What number should come next?
Answer: 10
3) **Look at this series: 36, 34, 30, 28, 24, ...** What number should come next?
Answer: 22
4) **Look at this series: 22, 21, 23, 22, 24, 23, ...** What number should come next?
Answer: 25
5) **Look at this series: 53, 53, 40, 40, 27, 27, ...** What number should come next?
Answer: 14
6) **Look at this series: 21, 9, 21, 11, 21, 13, 21, ...** What number should come next?
Answer: 15
7) **Look at this series: 58, 52, 46, 40, 34, ...** What number should come next?
Answer: 28
8) **Look at this series: 3, 4, 7, 8, 11, 12, ...** What number should come next?
Answer: 15
9) **Look at this series: 8, 22, 8, 28, 8, ...** What number should come next?
Answer: 34
10) **Look at this series: 31, 29, 24, 22, 17, ...** What number should come next?
Answer: 15
11) **Look at this series: 1.5, 2.3, 3.1, 3.9, ...** What number should come next?
Answer: 4.7
12) **Look at this series: 14, 28, 20, 40, 32, 64, ...** What number should come next?
Answer: 56
13) **Look at this series: 2, 4, 6, 8, 10, ...** What number should come next?
Answer: 12
14) **Look at this series: 201, 202, 204, 207, ...** What number should come next?
Answer: 211
15) **Look at this series: 544, 509, 474, 439, ...** What number should come next?
Answer: 404
16) **Look at this series: 80, 10, 70, 15, 60, ...** What number should come next?
Answer: 20
17) **Look at this series: 2, 6, 18, 54, ...** What number should come next?
Answer: 162
18) **Look at this series: 5.2, 4.8, 4.4, 4, ...** What number should come next?
Answer: 3.6
19) **Look at this series: 8, 6, 9, 23, 87 , ...** What number should come next?
Answer: 429

20) **28 25 5 21 18 5 14** ..... Which pair of numbers comes next?
Answer: 11 5
21) **8 11 21 15 18 21 22** ..... Which pair of numbers comes next?
Answer: 25 21
22) **9 16 23 30 37 44 51** ..... Which pair of numbers comes next?
Answer: 58 65
23) **2 8 14 20 26 32 38** ..... Which pair of numbers comes next?
Answer: 44 50
24) **9 11 33 13 15 33 17** ..... Which pair of numbers comes next?
Answer: 19 33
25) **2 3 4 5 6 4 8** ..... Which pair of numbers comes next?
Answer: 9 4
26) **17 17 34 20 20 31 23** ..... Which pair of numbers comes next?
Answer: 23 28
27) **6 20 8 14 10 8 12** ..... Which pair of numbers comes next?
Answer: 2 14
28) **21 25 18 29 33 18** ..... Which pair of numbers comes next?
Answer: 37 41
29) **75 65 85 55 45 85 35** ..... Which pair of numbers comes next?
Answer: 25 85
30) **11 16 21 26 31 36 41** ..... Which pair of numbers comes next?
Answer: 46 51
31) **3 8 13 18 23 28 33** ..... Which pair of numbers comes next?
Answer: 38 43
32) **84 78 72 66 60 54 48** ..... Which pair of numbers comes next?
Answer: 42 36
33) **20 20 17 17 14 14 11** ..... Which pair of numbers comes next?
Answer: 11 8
34) **61 57 50 61 43 36 61** ..... Which pair of numbers comes next?
Answer: 29 22
35) **9 12 11 14 13 16 15** ..... Which pair of numbers comes next?
Answer: 18 17
36) **4 8 22 12 16 22 20 24** ..... Which pair of numbers comes next?
Answer: 22 28
37) **40 40 31 31 22 22 13** ..... Which pair of numbers comes next?
Answer: 13 4
38) **1 10 7 20 13 30 19** ..... Which pair of numbers comes next?
Answer: 40 25
39) **10 20 25 35 40 50 55** ..... Which pair of numbers comes next?
Answer: 65 70
40) **42 40 38 35 33 31 28** ..... Which pair of numbers comes next?
Answer: 26 24
41) **6 10 14 18 22 26 30** ..... Which pair of numbers comes next?
Answer: 34 38

42) **8 12 9 13 10 14 11 ..... Which pair of numbers comes next?**
Answer: 15 12

43) **36 31 29 24 22 17 15 ..... Which pair of numbers comes next?**
Answer: 10 8

44) **3 5 35 10 12 35 17 ..... Which pair of numbers comes next?**
Answer: 19 35

45) **13 29 15 26 17 23 19 ..... Which pair of numbers comes next?**
Answer: 20 21

46) **14 14 26 26 38 38 50 ..... Which pair of numbers comes next?**
Answer: 50 62

47) **44 41 38 35 32 29 26 ..... Which pair of numbers comes next?**
Answer: 23 20

48) **34 30 26 22 18 14 10 ..... Which pair of numbers comes next?**
Answer: 6 2

49) **32 31 32 29 32 27 32 ..... Which pair of numbers comes next?**
Answer: 25 32

50) **7 9 66 12 14 66 17 ..... Which pair of numbers comes next?**
Answer: 19 66

51) **Fact 1: Most stuffed toys are stuffed with beans.**
Fact 2: There are stuffed bears and stuffed tigers.
Fact 3: Some chairs are stuffed with beans.
If the first three statements are facts, which of the following statements must also be a fact?
I: Only children's chairs are stuffed with beans.
II: All stuffed tigers are stuffed with beans.
III: Stuffed monkeys are not stuffed with beans.
Answer: None of the statements is a known fact.

52) **Fact 1: Mary said, "Ann and I both have cats."**
Fact 2: Ann said, "I don't have a cat."
Fact 3: Mary always tells the truth, but Ann sometimes lies.
If the first three statements are facts, which of the following statements must also be a fact?
I: Ann has a cat.
II: Mary has a cat.
III: Ann is lying.
Answer: All the statements are facts.

53) **Fact 1: Pictures can tell a story.**
Fact 2: All storybooks have pictures.
Fact 3: Some storybooks have words.
If the first three statements are facts, which of the following statements must also be a fact?
I: Pictures can tell a story better than words can.
II: The stories in storybooks are very simple.
III: Some storybooks have both words and pictures.
Answer: III only

54) **Fact 1: Some pens don't write.**
Fact 2: All blue pens write.
Fact 3: Some writing utensils are pens.
If the first three statements are facts, which of the following statements must also be a fact?
I: Some writing utensils don't write.
II: Some writing utensils are blue.
III: Some blue writing utensils don't write.
Answer: I and II only

55) **Fact 1: Islands are surrounded by water.**
Fact 2: Maui is an island.
Fact 3: Maui was formed by a volcano.
If the first three statements are facts, which of the following statements must also be a fact?
I: Maui is surrounded by water.
II: All islands are formed by volcanoes.
III: All volcanoes are on islands.
Answer: I only

56) **Fact 1: Robert has four vehicles.**
Fact 2: Two of the vehicles are red.
Fact 3: One of the vehicles is a minivan.
If the first three statements are facts, which of the following statements must also be a fact?
I: Robert has a red minivan.
II: Robert has three cars.
III: Robert's favorite color is red.
Answer: None of the statements is a known fact.

57) **Children are in pursuit of a dog whose leash has broken. James is directly behind the dog. Ruby is behind James. Rachel is behind Ruby. Max is ahead of the dog walking down the street in the opposite direction. As the children and dog pass, Max turns around and joins the pursuit. He runs in behind Ruby. James runs faster and is alongside the dog on the left. Ruby runs faster and is alongside the dog on the right. Which child is directly behind the dog?**
Answer: Max

58) **Nurse Kemp has worked more night shifts in a row than Nurse Rogers, who has worked five. Nurse Miller has worked fifteen night shifts in a row, more than Nurses Kemp and Rogers combined. Nurse Calvin has worked eight night shifts in a row, less than Nurse Kemp. How many night shifts in a row has Nurse Kemp worked?**
Answer: nine

59) **Danielle has been visiting friends in Ridge-wood for the past two weeks. She is leaving tomorrow morning and her flight is very early. Most of her friends live fairly close to the airport. Madison lives ten miles away. Frances lives five miles away, Samantha, seven miles. Alexis is farther away than Frances, but closer than Samantha. Approximately how far away from the airport is Alexis?**
Answer: six miles

60) **The high school math department needs to appoint a new chairperson, which will be based on seniority. Ms. West has less seniority than Mr. Temple, but more than Ms. Brody. Mr. Rhodes has more seniority than Ms. West, but less than Mr. Temple. Mr. Temple doesn't want the job. Who will be the new math department chairperson?**
Answer: Mr. Rhodes

61) **Four friends in the sixth grade were sharing a pizza. They decided that the oldest friend would get the extra piece. Randy is two months older than Greg, who is three months younger than Ned. Kent is one month older than Greg. Who should get the extra piece of pizza?**
Answer: Ned

62) **As they prepare for the state championships, one gymnast must be moved from the Level 2 team to the Level 1 team. The coaches will move the gymnast who has won the biggest prize and who has the most experience. In the last competition, Roberta won a bronze medal and has competed seven times before. Jamie has won a silver medal and has competed fewer times than Roberta. Beth has won a higher medal than Jamie and has competed more times than Roberta. Michele has won a bronze medal, and it is her third time competing. Who will be moved to the Level 1 team?**
Answer: Beth

63) **At the baseball game, Henry was sitting in seat 253. Marla was sitting to the right of Henry in seat 254. In the seat to the left of Henry was George. Inez was sitting to the left of George. Which seat is Inez sitting in?**
Answer: 251

64) **Ms. Forest likes to let her students choose who their partners will be; however, no pair of students may work together more than seven class periods in a row. Adam and Baxter have studied together seven class periods in a row. Carter and Dennis have worked together three class periods in a row. Carter does not want to work with Adam. Who should be assigned to work with Baxter?**
Answer: Carter

65) **Four people witnessed a mugging. Each gave a different description of the mugger. Which description is probably right?**
Answer: He was tall, thin, and middle-aged.

66) **In a four-day period Monday through Thursday each of the following temporary office workers worked only one day, each a different day. Ms. Johnson was scheduled to work on Monday, but she traded with Mr. Carter, who was originally scheduled to work on Wednesday. Ms. Falk traded with Mr. Kirk, who was originally scheduled to work on Thursday. After all the switching was done, who worked on Tuesday?**
Answer: Mr. Kirk

67) **A four-person crew from Classic Colors is painting Mr. Field's house. Michael is painting the front of the house. Ross is in the alley behind the house painting the back. Jed is painting the window frames on the north side, Shawn is on the south. If Michael switches places with Jed, and Jed then switches places with Shawn, where is Shawn?**
Answer: in front of the house

68) **Four defensive football players are chasing the opposing wide receiver, who has the ball. Calvin is directly behind the ball carrier. Jenkins and Burton are side by side behind Calvin. Zeller is behind Jenkins and Burton. Calvin tries for the tackle but misses and falls. Burton trips. Which defensive player tackles the receiver?**
Answer: Jenkins

69) **A jar of jelly beans contains more red beans than green. There are more yellow beans than red. The jar contains fewer yellow jelly beans than green ones. If the first two statements are true, the third statement is**
Answer: false

70) **The bookstore has a better selection of postcards than the newsstand does. The selection of postcards at the drugstore is better than at the bookstore. The drugstore has a better selection of postcards than the bookstore or the newsstand. If the first two statements are true, the third statement is**
Answer: true

71) **At a parking lot, a sedan is parked to the right of a pickup and to the left of a sport utility vehicle. A minivan is parked to the left of the pickup. The minivan is parked between the pickup and the sedan. If the first two statements are true, the third statement is**
Answer: false

72) **Cloudy days tend to be morewindy than sunny days. Foggy days tend to be less windy than cloudy days. Sunny days tend to be less windy than foggy days. If the first two statements are true, the third statement is**
Answer: uncertain

73) **Taking the train across town is quicker than taking the bus. Taking the bus across town is slower than driving a car. Taking the train across town is quicker than driving a car. If the first two statements are true, the third statement is**
Answer: uncertain

74) **Three pencils cost the same as two erasers. Four erasers cost the same as one ruler. Pencils are more expensive than rulers. If the first two statements are true, the third statement is**
Answer: false

75) **Tom puts on his socks before he puts on his shoes. He puts on his shirt before he puts on his jacket. Tom puts on his shoes before he puts on his shirt. If the first two statements are true, the third statement is**
Answer: uncertain

76) **A toothpick is useful. Useful things are valuable. A toothpick is valuable. If the first two statements are true, the third statement is**
Answer: true

77) **The hotel is two blocks east of the drugstore. The market is one block west of the hotel. The drugstore is west of the market. If the first two statements are true, the third statement is**
Answer: true

78) **All Lamels are Signots with buttons. No yellow Signots have buttons. No Lamels are yellow. If the first two statements are true, the third statement is**
Answer: true

79) All spotted Gangles have long tails. Short-haired Gangles always have short tails. Long-tailed Gangles never have short hair. If the first two statements are true, the third statement is
Answer: uncertain

80) Middletown is north of Centerville. Centerville is east of Penfield. Penfield is northwest of Middletown. If the first two statements are true, the third statement is
Answer: false

81) Spot is bigger than King and smaller than Sugar. Ralph is smaller than Sugar and bigger than Spot. King is bigger than Ralph. If the first two statements are true, the third statement is
Answer: false

83) Martina is sitting in the desk behind Jerome. Jerome is sitting in the desk behind Bryant. Bryant is sitting in the desk behind Martina. If the first two statements are true, the third statement is
Answer: false

84) Oat cereal has more fiber than corn cereal but less fiber than bran cereal. Corn cereal has more fiber than rice cereal but less fiber than wheat cereal. Of the three kinds of cereal, rice cereal has the least amount of fiber. If the first two statements are true, the third statement is
Answer: true

85) The temperature on Monday was lower than on Tuesday. The temperature on Wednesday was lower than on Tuesday. The temperature on Monday was higher than on Wednesday If the first two statements are true, the third statement is
Answer: uncertain

86) On the day the Barton triplets are born, Jenna weighs more than Jason. Jason weighs less than Jasmine. Of the three babies, Jasmine weighs the most. If the first two statements are true, the third statement is
Answer: uncertain

87) Joe is younger than Kathy. Mark was born after Joe. Kathy is older than Mark. If the first two statements are true, the third statement is
Answer: true

88) The Shop and Save Grocery is south of Greenwood Pharmacy. Rebecca's house is northeast of Greenwood Pharmacy. Rebecca's house is west of the Shop and Save Grocery. If the first two statements are true, the third statement is
Answer: false

89) A fruit basket contains more apples than lemons. There are more lemons in the basket than there are oranges. The basket contains more apples than oranges. If the first two statements are true, the third statement is
Answer: true

90) Class A has a higher enrollment than Class B. Class C has a lower enrollment than Class B. Class A has a lower enrollment than Class C. If the first two statements are true, the third statement is
Answer: false

91) All the offices on the 9th floor have wall-to-wall carpeting. No wall-to-wall carpeting is pink. None of the offices on the 9th floor has pink wall-to-wall carpeting. If the first two statements are true, the third statement is
Answer: true

92) Rover weighs less than Fido. Rover weighs more than Boomer. Of the three dogs, Boomer weighs the least. If the first two statements are true, the third statement is
Answer: true

93) During the past year, Josh saw more movies than Stephen. Stephen saw fewer movies than Darren. Darren saw more movies than Josh. If the first two statements are true, the third statement is
Answer: uncertain

94) All the tulips in Zoe's garden are white. All the pansies in Zoe's garden are yellow. All the flowers in Zoe's garden are either white or yellow If the first two statements are true, the third statement is
Answer: uncertain

95) The Kingston Mall has more stores than the Galleria. The Four Corners Mall has fewer stores than the Galleria. The Kingston Mall has more stores than the Four Corners Mall. If the first two statements are true, the third statement is
Answer: true

96) Apartments in the Riverdale Manor cost less than apartments in The Gaslight Commons. Apartments in the Livingston Gate cost more than apartments in the Gaslight Commons. Of the three apartment buildings, the Livingston Gate costs the most. If the first two statements are true, the third statement is
Answer: true

97) Mara runs faster than Gail. Lily runs faster than Mara. Gail runs faster than Lily. If the first two statements are true, the third statement is
Answer: false

98) All the trees in the park are flowering trees. Some of the trees in the park are dogwoods. All dogwoods in the park are flowering trees. If the first two statements are true, the third statement is
Answer: true

99) Blueberries cost more than strawberries. Blueberries cost less than raspberries. Raspberries cost more than both strawberries and blueberries. If the first two statements are true, the third statement is
Answer: true

100) Tanya is older than Eric. Cliff is older than Tanya. Eric is older than Cliff. If the first two statements are true, the third statement is
Answer: false

Analytical Reasoning

Questions 1 to 5 are based on the following:
Five persons are sitting in a line. One of the two persons, at the farthest ends, is sharp, the other one is fair. An overweight person is sitting to the right of a feeble person. A tall person is to the left of the fair person and the feeble person is sitting between the sharp and overweight persons.

1) **Tall person is at which place counting from right?**

(a) First
(b) Second
(c) Third
(d) Fourth
(e) Cannot be determined

Answer (b)

2) **Which of the following depicts the person to the left of feeble person?**

(a) Sharp
(b) Overweight
(c) Fair
(d) Tall
(e) Cannot be determined

Answer (a)

3) **Which of the following persons is sitting in the middle?**

(a) Fair
(b) feeble
(c) sharp
(d) Tall
(e) Overweight

Answer (e)

4) **To whose left is the overweight person sitting?**

(a) Fair
(b) Sharp
(c) Tall
(d) feeble
(e) Cannot be determined

Answer (c)

5) **If the fair person and overweight person swap their position, so also tall and feeble, then who will be sitting to the left of the feeble person?**

(a) Tall
(b) Fair
(c) Overweight
(d) Sharp
(e) Cannot be determined

Answer (b)

6) **Junaid's ranks seventh from the top and 28th from the bottom in a class. How many students are there in the class?**

(a) 36
(b) 35
(c) 34
(d) Cannot be determined
(e) None of the above

Answer: (e)

7) **Sibite is taller than Tariq. Lashari is taller than Rizwan. Rizwan is taller than Asif. To determine who among them is the tallest, which of the following further information, if any, is required?**

(a) Sibite is taller than Asif and Rizwan
(b) No further information is needed
(c) Lashari is taller Tariq
(d) Sibite is taller than Rizwan
(e) Asif is taller than Tariq

Answer: (e)

8) **Four of the following five are similar in a definite way and so form a group. Which one of them does not belong to the group?**

(a) Umbrella
(b) Gloves
(c) Shirt
(d) Shoes
(e) Cap

Answer: (a)

9) **There are 26 steps in a Shop. In the time Shahzad comes down two steps, Tariq goes one step. If they start simultaneously and keep their speed uniform, then at which step from bottom will they meet.**

(a) 9th
(b) 12th
(c) 13th
(d) 8th
(e) None of the above

Answer: (a)

Assume they meet at Xth step from the bottom, and this is equal to number of steps downward plus number of step upward minus common step (which will be added two times)

Therefore 2*2+2*1-1=26

Therefore X= 9

10) **In certain code Language the words ROUTINE is written as VMRGFLI. How will the word CRUELTY be written in that code language?**

(a) VOCVZRL
(b) WPCVZRL
(c) VPCVZRL
(d) VPVCZRL
(e) None of the above

Answer: (c)

The first alphabet becomes the third alphabet, second alphabet is coded as -2, and the third alphabet becomes first after +1. A similar relationship exists between the last three alphabets. A for the center alphabet, it is coded as the same positioned alphabet from the right end of the letter.

Question 11 and 12
You are required to answer these questions referring to the symbol, alphabet or number sequence given below.
P Y 4 # A Q © K B 8 D 5 * E % 2 S ? 9 R U $ F @ 6 H M 3 W (X)

11) **If all the symbols are dropped from the sequence, then which element will be in the center in the new sequence?**

(a) 5
(b) E
(c) 2
(d) S
(e) There is no center element

Answer: (e)

P Y 4 A Q K B 8 D 5 E 2 S 9 R U F 6 H M 3 W. We can see that number of elements is even number (22), there is no center element possible.

12) **8 is related to? W in the same way as BE is related to?**

(a) S?
(b) 6M
(c) W(x)
(d) $3
(e) None of the above

Answer: (e)

Number of elements between the second pair of elements is double with respect to the number of elements between the first pair of elements.

All the question given below has two words which have definite relationship to each other, followed by five alphabets pairs of associated words. Choose the alphabets pair of words

13) **Degree: Angle**
(a). area : square inch
(b) milk : quart
(c). civilization : classes
(d). letter : alphabet
(e). time : minutes

Answer: (a)

14) **Confirmed : Ingrained**
(a).awareness : theoretical
(b). financial : bankrupt
(c). undeveloped : immature
(d). believable : unbelievable
(e). wary: grueling

Answer: (b)

15) **Lullaby : Barcarole**
(a). birth : marriage
(b). night : sunrise
(c). cradle : gondola
(d). song : verse
(e). song : sonneteer

Answer: (c)

16) **Zoology : Animals**
(a). ecology : pollution
(b). botany : trees
(c). chemistry : molecule
(d). Past : public
(e). mathematics : arithmetic

Answer: (a)

17) **Dory : Van**
(a). dairy : buffalo
(b). fish : bus
(c). freighter : caisson
(d). runners : bat
(e). Danish : Dutch

Answer: (c)

In these particular questions there are given some statements, followed by the conclusion which appeals you to be the most correct.

18) **Nitrogen gas is lighter than oxygen. Nitrogen gas is lighter than Helium. Therefore, oxygen is the heaviest of the three gases.**
(a) Can't say
(b) True
(c) False
(d) Probably true
(e)None of the above

Answer: (a)

19) **The presence of calcium in milk makes it white. Rice too is white in color. Therefore, rice also contains calcium.**
(a) Can't say
(b) True
(c) False
(d) Probably true
(e) None of the above

Answer: (a)

20) **Soap is used for washing because**
(a) The advertising is powerful
(b) Its shape is convenient
(c) It dissolves dirt in water more easily
(d) The perfume is pleasant
(e) None of the above

Answer: (c)

21) **Ice floats on water because**
(a) It is spongy
(b) It is transparent
(c) It is an element which melts easily
(d) Its weight is less than the weight of water of equal volume
(e) None of the above

Answer: (d)

22) **At midnight, you heard the voice of several people shouting "fire". Which of the following you would do?**
(a) Ensure where the fire had taken place and to what extent
(b) Continue to sleep till you are called for
(c) Rush out of the room with buckets of water to extinguish the fire
(d) Rush to the fire brigade station and inform the officials about the fire
(e) None of the above

Answer: (a)

23) **You have been asked to appoint a personal secretary. Which of the following quality would you consider as most important?**
(a) She must have good experience
(b) She must have an imposing personality
(c) She must be highly educated
(d) She must be an efficient stenographer
(e) None of the above

Answer: (a)

24) **While riding on a scooter, you find someone has been hurt by your scooter. Which of the following will be your responsibility?**
(a) Pay compensation for the injury and try to dispose the matter
(b) Try to run away from the spot immediately
(c) Take him to the Doctor and arrange for the medical aid
(d) Stop your vehicle and say sorry
(e) None of the above

Answer: (c)

25) **Generally a patient of tuberculosis visits the hill stations because**
(a) They are advised by the Physicians to do so
(b) It is pleasure to enjoy the environment
(c) Atmospheric pressure decreases with the height from the sea level
(d) Cold weather is favorable for the patients of tuberculosis
(e) None of the above

Answer: (c)

26) **Snakes and hawks are the predators of mice in the field. Dogs which also feed on mice are bought on the scene. What will be the immediate result?**
(a) Increase in the number of snakes
(b) Decrease in the number of snakes and hawks
(c) Decrease in the number of mice
(d) Decrease in the number of dogs
(e) None of the above

Answer: (c)

27) **Average family income in the cities has increased today as compared to the last few years, as in most families these days' husbands and wives are working. This sentences implies all the following except**
(a) Family income level was lower few years ago
(b) Wives earn more than husbands today
(c) It was more prevalent for one spouse to work earlier than today
(d) More husbands and wives are working today as compared to last few years
(e) None of the above

Answer: (b)

28) **Team sports like cricket, display socialist tendencies in their requirements of individual subordination to the authority of coaches and managers. Which of the following conclusion may not be inferred from the above information?**
(a) All team sports have socialist tendencies
(b) All team sports are authoritarian
(c) Without employee subordination to managerial authority, production for profit would not be possible
(d) All team players are subordinate to their coaches
(e) None of the above

Answer: (c)

29) **If in your college hostel mess, you find that the vegetable curry being served for the last ten days is having a lot of stones and you are fed up with it. What will you do?**
(a) Buy your own vegetables and cook it in your room
(b) Leave consuming the vegetables altogether
(c) Speak with cook to change the vegetable
(d) Bring the matter to the notice of the mess in charge and if nothing is done by him, then inform the hostel administration
(e)None of the above

Answer: (d)

30) **From 1940 to 1970, the amount of food production per worker and per hour increased two fold. From 1970 to 2000, food production per worker and per hour increased one and a half times. Each of the following, if true, could help to account for this trend except**
(a) More workers were needed to produce the same unit of output
(b) The number of farm workers increased
(c) The number of hours worked per unit of output decreased
(d) The use of chemical fertilizers decreased
(e) None of the above

Answer: (b)

31) **Starting in 1985, all drivers had to wear helmets if they have to drive a two wheeler. From which of the following can this statement be properly inferred?**
(a) Some drivers may have worn helmets before 1985, but all two wheeler drivers were required to wear them beginning in 1985
(b) No drivers had to wear helmets before 1985
(c) Two wheelers drivers were the first to be required to wear helmets
(d) Two wheelers drivers had to wear helmets prior to 1985
(e) None of the above

Answer: (a)

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32) **In 1970, the average child visited the dentist once a year. By 1990 the number of visits increased to two. Today, the average child visits the dentist three times a year. Each of the following, if true, could explain this trend except.**
a) Better home care of teeth has reduced the number of cavities
(b) Dentist fee have declined over the period
(c) Parents are more aware of the importance of dental care
(d) Dental care has become less painful
(e) None of the above

Answer: (c)

From questions 33 to 37, one word in each sentence is italicized. Choose the correct word which may improve the sentence and if there is no improvement required then your sentence should be (e)

33) **He opened the letter without caring to read the address on envelop.**
(a) Thinking (b) Bothering (c) Worrying (d) Knowing (e) No improvement

Answer (b)

34) **She gave most of her time to composition.**
(a) Lent (b) Devoted (c) Spent (d) Spend (e) No improvement

Answer (b)

35) **The parents became very troubled when their son did not return by late night.**
(a) Depressed (b) Sad (c) Anxious (d) Worried (e) No improvement

Answer (c)

36) **This particular matter must be regarded in every point of view.**
(a) From (b) With (c) At (d) By (e) No improvement

Answer (a)

37) **She did not ask any questions to him.**
(a) To him any question (b) Any question from him
(c) Him any question (d) Any question for him
(e) No improvement

Answer (c)

In the following questions, from 38 to 42, a group of words is given in each question. Below four words are given. Find the appropriate alternatives which can substitute the given words. Find the suitable options which can substitute the given words.

38) **Parts of a country behind the coast or a river's banks**
(a) Swamps (b) Isthmus (c) Archipelago (d) Hinterland (e) None of the above

Answer (d)

39) **A person who knows many languages**
(a) Polyglot (b) Grammarian (c) Bilingual (d) Linguist (e) None of the above

Answer (d)

40) **That which cannot be read**
(a) Negligible (b) Incorrigible (c) Illegible (d) Ineligible (e) None of the above.

Answer (c)

41) **Study of the evolution of man as an animal**
(a) Ethnology (b) Anthropology (c) Chronology (d) Archaeology (e) None of the above

Answer (b)

42) **To cause troops, etc. to plead out in readiness for battle**
(a) Deploy (b) Align (c) Disperse (d) Collocate (e) None of the above
Answer (a)

Questions from 43 to 47
Fill in the blanks with appropriate words

43) **As ice is related to coolness in the same way as Earth is related to ——**
(a) Gravitation (b) Weight (c) Ocean (d) Forest
Answer (a)

44) **As North Pole is related to Magnet, in the same way —— is related to Battery.**
(a) Terminal (b) Power (c) Energy (d) Cell
Answer (d)

45) **Find the missing number in the following series.**
6, 12, 21, —, 48
(a) 40 (b) 33 (c) 38 (d) 45
Answer (d)

46) **Which one is different from rest three?**
(a) Scooter (b) Cycle (c) Car (d) Tonga
Answer (c)

47) **Arrange the following words in a meaningful order:**
Platinum, Gold, Iron, Diamond, Sand
(a) 5 4 3 2 1 (b) 2 4 3 5 1 (c) 4 5 1 3 2 (d) 3 2 1 5 4
Answer (d)

Questions from 48 to 52, choose the one option which best expresses the meaning of the given word.

48) **Gratify**
(a) Pacify (b) Appreciate (c) Indulge (d) Frank
Answer (a)

49) **Extricate**
(a) Complicate (b) Pull (c) Free (d) Tie
Answer (c)

50) **Inexplicable**
(a) Chaotic (b) Unaccountable (c) Confusing (d) Unconnected
Answer (b)

51) **Insolvent**
(a) Broke (b) Poor (c) Penniles (d) Bankrupt
Answer (d)

52) **Stringent**
(a) Shrill (b) Dry (c) Rigorous (d) Strained
Answer (c)

In the Question 53 to 57, sentences are given with blanks are to be filled in with an appropriate word. Four options are suggested for each question. Select the right alternative out of the four

53) **Bilal had he arrived—— it started raining.**
(a) When (b) After (c) Before (d) Than
Answer (d)

54) **He tried to —— himself against a group of ruffians**
(a) Support (b) Collect (c) Defend (d) Save
Answer (d)

55) **My aunty decided to take —— and my sister to the market.**
(a) Mine (b) Myself (c) I (d) Me
Answer (d)

56) **Find the —— of the news.**
(a) Headings (b) Topics (c) Titles (d) Captions
Answer (a)

57) **During Eid days the shops are —— of people.**
(a) Crowded (b) Busy (c) Bubbling (d) Full
Answer (d)

58) **Which of the following is different from the rest three?**
(a) Shrub (b) Flower (c) Tree (d) Herb (e) None of the above
Answer (c)

59) **Which one of the following differs from the rest three?**
(a) FHUJU (b) YNHIA (c) ISEPU (d) SGRFI (e) None of the above
Answer (a)

60) **Find that pair of numbers which is not related to the other pairs of numbers due to lack of some common property.**
(a) 57, 69 (b) 42, 29 (c) 47, 59 (d) 73, 61 (e) None of the above
Answer (b)

61) **Which one of the following differs from the rest of the three?**
(a) TSGH (b) ZAYB (c) VEUF (d) XCWD (e) None of the above
Answer (a)
(A) = ZA/YB. A and Z are the first and last alphabets. Y and B are the second alphabets from the end and from the beginning and so on, therefore TSGH differs.

Mental Ability

Mental Abilities Scale

The mental abilities scales are not an IQ test. They provide information about an individual's ability to learn new information which can be an important aspect in jobs that have to address changing circumstances and new information.

The four mental ability scales measured by the ICES Plus Assessment are:

1. **General Ability**: measures a person's capacity to deal with ideas, to solve problems and to assimilate new information. It is an indication of how well a person thinks ahead to anticipate the effects of actions and decisions and how quickly he or she learns.
2. **Working with Numbers**: is an evaluation of numerical reasoning ability. It shows how well an individual reasons with new information, data and numbers. It indicates the ability to reason logically and solve problems.
3. **Working with Words**: relates to reasoning with and using written language effectively. It is an indication of written communication skills.
4. **Working with Shapes**: has to do with spatial skills, or how well a person is able to manipulate objects, both physically and visually. It is an indication of a person's ability to think and reason in three dimensions.

1) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Asia (b) Australia (c) Antarctica (d) Africa (e) Austria
Answer: (e)

2) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Copper (b) Iron (c) Aluminum (d) Zinc (e) Steel
Answer: (e)

3) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Snake (b) Crocodile (c) Frog (d) Lizard (e) Fish
Answer: (d)

4) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Sand (b) Cement (c) Building (d) Wood (e) Bricks
Answer: (c)

5) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Mica (b) Zinc (c) Iron (d) Chlorine (e) Aluminum
Answer: (d)

6) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Coconut (b) Lotus (c) Lilly (d) Rose (e) Marigold
Answer: (a)

7) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Table (b) Chair (c) Bench (d) Desk (e) Wood
Answer: (e)

8) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Clove (b) Cinnamon (c) Pepper (d) Cardamom (e) Apricot
Answer: (e)

9) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Sodium (b) Chlorine (c) Magnesium (d) Nitrogen (e) Glucose
Answer: (e)

10) **Four of the following five are alike in a certain way and so form a group. Which is the one that does not belong to that group?**
(a) Radish (b) Carrot (c) Garlic (d) Gourd (e) Ginger
Answer: (d)

11) **A is father of C and D is son of B. E is brother of A. If C is sister of D, how is B related to E?**
(a) Daughter (b) Brother-in-Law (c) Husband (d) Sister-in-Law
Answer: (a)

12) **A girl introduced a boy as the son of the daughter of the father of her uncle. The boy is girl`s**
(a) Brother (b) Son (c) Uncle (d) Son-in-law
Answer: (a)

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